The Journal of Bone and Joint Surgery

The Official Publication of

The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
South African Orthopaedic Association
Western Orthopedic Association

MARCH 1961

American Volume
Vol. 43-A, No. 2

8 THE FENWAY, BOSTON 15, MASSACHUSETTS, U. S. A.
BRITISH OFFICE:
82 PORTLAND PLACE, LONDON, W. 1, ENGLAND

The Journal of Bone and Joint Surgery

PUBLISHED IN TWO VOLUMES

WILLIAM A. ROOBERS, *Editor-in-Chief Emeritus*

AMERICAN VOLUME

Editor and Chairman Board of Editors: THORNTON BROWN

American Board of Associate Editors

LENOX D. BAKER, Durham, North Carolina
WILLIAM H. BICKEL, Rochester, Minnesota
DAVID M. BOSWORTH, New York, N. Y.
JOSEPH H. BOYES, Los Angeles, California
JOE B. DAVIS, Portland, Oregon
WILLIAM F. DONALDSON, Pittsburgh, Pennsylvania
ALBERT B. FERGUSON, JR., Pittsburgh, Pennsylvania
CHARLES H. FRANTZ, Grand Rapids, Michigan
HALSTED HALLOCK, New York, N. Y.
CHARLES H. HERNDON, Cleveland, Ohio
JOHN WILLIAM HILLMAN, Nashville, Tennessee
EMANUEL B. KAPLAN, New York, N. Y.
DON KING, San Francisco, California
WILLIAM A. LARMON, Chicago, Illinois
WILLIAM R. MACAUSLAND, JR., Boston, Massachusetts
PAUL E. MCMASTER, Beverly Hills, California
C. LESLIE MITCHELL, Detroit, Michigan
FRED C. REYNOLDS, St. Louis, Missouri
DANIEL C. RIORDAN, New Orleans, Louisiana
WAYNE O. SOUTHWICK, New Haven, Connecticut
O. SHERWIN STAPLES, Hanover, New Hampshire
JACK K. WICKSTROM, New Orleans, Louisiana

BRITISH VOLUME

SIR REGINALD WATSON-JONES, *Editor*

British Editorial Board

SIR WALTER MERCER, *Chairman*
H. JACKSON BURROWS, *Deputy Editor*
J. CRAWFORD ADAMS, *Assistant Editor*
W. D. COLTART, *Treasurer*
C. E. L. ALLEN, Cape Town, South Africa
ROLAND BARNES, Glasgow, Scotland
J. S. BATCHELOR, London, England
JOHN CHARNLEY, Manchester, England
F. P. DEWAR, Toronto, Canada
J. KENNEDY ELLIOTT, Wellington, New Zealand
E. MERVYN EVANS, Swansea, Wales
A. L. EYRE-BROOK, Bristol, England
ROOME GARIÉPY, Montreal, Canada
B. KRON-COHEN, Melbourne, Australia
K. I. NIMEN, London, England
DOUGLAS PARKES, Hobart, Tasmania
R. G. PULVERTAFT, Derby, England
H. J. SEDDON, London, England
E. W. SOMERVILLE, Oxford, England
GORONWY THOMAS, Liverpool, England
O. J. VAUGHAN-JACKSON, London, England

Corresponding Editors

Argentina: JOSÉ VALLS
Austria: WALTHER EHALT
Belgium: JEAN VERBRUGGE
Brazil: F. E. GODOY MOREIRA
Cuba: ALBERTO INCLÁN
Denmark: JOHANNES MORTENS
Finland: K. E. KALLIO
France: R. MERLE D'AUBIGNÉ
Germany: MATHIAS HACKENBROCH
Italy: O. SCAGLIETTI
Japan: EISHI KONDO
Mexico: JUAN FARILL
Netherlands: J. D. MULDER
Poland: ADAM GRUCA
Portugal: ARNALDO RODO
Sweden: STEN FRIBERG
Uruguay: JOSÉ LUIS BADO

Committees

THE JOURNAL OF BONE AND JOINT SURGERY, INCORPORATED

The American Orthopaedic Association

The American Academy of Orthopaedic Surgeons

BOARD OF TRUSTEES

KEENE O. HALDEMAN, *Vice-Chairman*
H. RELTON MCCARROLL, *Treasurer*
JOSEPH A. FREIBERG, *Secretary*
THORNTON BROWN, *Editor*
R. BEVERLY RANEY
H. HERMAN YOUNG
JOHN ROYAL MOORE

American Society for Surgery of the Hand
President: DANIEL C. RIORDAN
President-Elect: GEORGE S. PHALEN
Secretary-Treasurer: DON L. EYLER
1919 Hayes Street, Nashville 4, Tennessee

The Australian Orthopaedic Association
W. L. MACDONALD, *President*
R. MCKELLAR HALL, *President-Elect*
A. I. RHYDDERCH, *Editorial Secretary*
RICHARD HODGKINSON, *Secretary*, 135 Macquarie Street, Sydney, New South Wales

The British Orthopaedic Association
H. J. SEDDON, *President*
SIR REGINALD WATSON-JONES, *Editor*
E. W. SOMERVILLE, *Editorial Secretary*
J. CRAWFORD ADAMS, *Secretary*
47 Lincoln's Inn Fields, London, W.C. 2

The Canadian Orthopaedic Association
E. W. EWERT, Moncton, *President*
R. G. TOWNSEND, Calgary, *Vice-President*
IAN W. DAVIDSON, *Secretary-Treasurer*
130 Elm Street, Sudbury, Ontario
F. P. DEWAR, *Editorial Secretary*
706 Medical Arts Building, Toronto, Ontario

New Zealand Orthopaedic Association
J. KENNEDY ELLIOTT, Wellington, *President*
J. M. SAUNDERS, Wellington, *Secretary-Treasurer*
ALAN ALLDRED, *Editorial Secretary*
475, George Street, Dunedin

South African Orthopaedic Association
R. C. J. HILL, *President*
N. M. THOMPSON, *Treasurer*
CYRIL KAPLAN, *Secretary*, 71 Trust Building, Gardiner Street, Durban, South Africa

Western Orthopedic Association
President: MARVIN P. KNIGHT
President-Elect: DON KING
Secretary: B. CLYDE HALLEY, JR.,
3707 Gaston Avenue, Dallas 10, Texas

Published in the United States by The Journal of Bone and Joint Surgery, Incorporated

Published in the United Kingdom for The British Editorial Society of Bone & Joint Surgery by E. & S. Livingstone, Teviot Place, Edinburgh

THE JOURNAL OF BONE AND JOINT SURGERY

American Office
8 The Fenway, Boston 15, Massachusetts, U.S.A.
Managing Editor: John A. Reed
Assistant Editor: H. Stephen Tilton

British Office
82 Portland Place, London, W. 1, England
Editorial Secretary: Jean Barnes

The Journal of Bone and Joint Surgery*

American Volume

TABLE OF CONTENTS

March 1961

PAGE

Observations on Non-Union of the Shafts of the Long Bones, with a Statistical Analysis of 842 Patients.
By *Harold B. Boyd, M.D., S. W. Lipinski, M.D.,* and *James H. Wiley, M.D.,* Memphis, Tennessee 159

The Fabellofibular and Short Lateral Ligaments of the Knee Joint.
By *Emanuel B. Kaplan, M.D.,* New York, N. Y. 169

The Developmental Origin of Spondylolisthesis. Two Case Reports.
By *Lewis Cozen, M.D.,* Los Angeles, California 179

Ewing's Sarcoma. A Critical Analysis of 165 Cases.
By *David C. Dahlin, M.D., Mark B. Coventry, M.D.,* and *Paul W. Scanlon, M.D.,* Rochester, Minnesota 185

Acute Arterial Injuries Due to Blunt Trauma.
By *Harold A. Collins, M.D.,* and *J. Kenneth Jacobs, M.D.,* Nashville, Tennessee 193

Quadriplegia Due to Guinea-Worm Abscess.
By *James R. Donaldson, M.D.,* and *Thomas A. Angelo, M.B., B.S.,* Miraj, Bombay State, India 197

Bilateral Osteosarcoma in the Phalanges of the Hand. A Solitary Case Report.
By *Benjamin W. Drompp, M.D.,* Detroit, Michigan 199

An Adjustable Lower-Extremity Brace.
By *Thomas L. DeLorme, M.D., Laird Johnson, B.S., Peter Luchini, B.S., William Bora, M.D.,* and *James Morrissey, M.D.,* Boston, Massachusetts 205

Operative Treatment for Recurrent Dislocation of the Temporomandibular Joint.
By *Caroll M. Silver, M.D.* and *Stanley D. Simon, M.D.,* Providence, Rhode Island 211

Congenital Elevation of the Scapula. Correction by Release and Transplantation of Muscle Origins. A Preliminary Report.
By *Joe W. Woodward, M.D.,* Waco, Texas 219

(*Continued on page 3*)

The Journal of Bone and Joint Surgery (American Volume) is issued eight times a year—in January, March, April, June, July, September, October, and December. The 1961 subscription price, payable in advance, is $14.50. Single copies $3.00.
The Journal of Bone and Joint Surgery, second-class postage paid at Boston, Mass. and at additional mailing offices. Editorial and business offices, 8 The Fenway, Boston, Mass. Accepted at the special rate of postage provided for in the act of February 28, 1925, Paragraph 4, Section 412, Postal Laws and Regulations; authorized April 21, 1932. Additional entry at Concord, New Hampshire, authorized June 10, 1947.

Copyright 1961 by *The Journal of Bone and Joint Surgery, Incorporated*
*TITLE REGISTERED IN UNITED STATES PATENT OFFICE

The Journal of Bone and Joint Surgery WELCOMES ARTICLES WHICH CONTRIBUTE TO ORTHOPAEDIC SCIENCE FROM ALL SOURCES IN ALL COUNTRIES

- Articles are accepted only for exclusive publication in *The Journal of Bone and Joint Surgery*.
- Publication does not constitute official endorsement of opinions presented in articles.
- Articles published and their illustrations become the property of *The Journal*.

WHEN YOU SUBMIT AN ARTICLE PLEASE SEND:

1. THE ORIGINAL MANUSCRIPT AND, IF POSSIBLE, DUPLICATE MANUSCRIPTS COMPLETE WITH ILLUSTRATIONS. THE EXTRA COPIES WILL GREATLY ACCELERATE EDITORIAL DECISION. Keep a copy. Manuscripts of accepted articles will not be returned.
2. BIBLIOGRAPHY, alphabetical, of references made in text *only*. Please refer to bibliographies in this copy of *The Journal* and follow style exactly.
3. LEGENDS for all illustrations submitted, listed in order.
4. ILLUSTRATIONS
   a. *Black and white glossy prints* of photographs.
   b. *Original* drawings or charts.
   c. *Magnification* of photomicrographs.

NOTES ON PREPARATION OF MANUSCRIPT

- Manuscripts must be typewritten, double-spaced with wide margins.
- Write out figures under 100 except percentages, degrees, or figures expressed in decimals.
- Direct quotations should include exact page numbers on which quotation appeared in book or article.

NOTES ON PREPARATION OF ILLUSTRATIONS

- Number all illustrations.
- Indicate *top* plainly.
- Write author's name on the back of each one.
- Put dates or initials in *Legends*, not on prints.
- Send prints unmounted or mounted only with rubber cement. Paste or glue will damage prints.
- Drawings, charts, and lettering on prints should be done with black India ink. Use white India ink on black backgrounds.
- Make lettering large enough to be read when drawings are reduced.
- When submitting an illustration which has appeared elsewhere give full information about previous publication, credit to be given, and state whether or not permission to reproduce has been obtained.

COPYRIGHT

Material appearing in *The Journal* is covered by copyright. As a general rule permission will be given to reputable medical journals to reprint anything in these pages, if permission is first obtained from *The Journal* and if the material used is properly credited to *The Journal*.

MIMEOGRAPHED BROCHURE. "Writing for *The Journal of Bone and Joint Surgery*" WILL BE SENT ON REQUEST.

Manuscripts submitted for publication in the AMERICAN VOLUME should be sent to The Editor, *The Journal of Bone and Joint Surgery*, 8 The Fenway, Boston 15, Massachusetts.
Manuscripts submitted for publication in the BRITISH VOLUME should be sent to The Editor, *The Journal of Bone and Joint Surgery*, 82 Portland Place, London, W. 1, England.

TABLE OF CONTENTS

(*Continued from page 1*)

PAGE

The Surgical Treatment of Injuries of the Fibular Collateral Ligaments of the Ankle.
By *Charles J. Ruth, M.D.*, Fremont, California 229

A Locking Little Finger.
By *Adrian E. Flatt, M.D., F.R.C.S.*, Iowa City, Iowa 240

Male Sex Hormone and Osteo-Arthrosis in Mice.
By *Ruth Silberberg, M.D.*, and *Martin Silberberg, M.D.*, St. Louis, Missouri 243

Legg-Calvé-Perthes Disease—Factors in Healing.
By *E. L. Ralston, M.D.*, Philadelphia, Pennsylvania 249

Legg-Calvé-Perthes Disease—Pathogenesis and Evolution. Failure of Treatment with L-Triiodothyronine.
By *Ignacio V. Ponseti, M.D.*, and *Ralph L. Cotton, M.D.*, Iowa City, Iowa 261

Isolated Displaced Fracture of the Posterior Facet of the Talus.
By *J. H. Dimon, M.D.*, Boston, Massachusetts 275

A Foreign Body in a Tendon Sheath. A Case Report.
By *Amin Rida, M.Ch.Orth.* (*Alex.*), Alexandria, Egypt, United Arab Republic 282

Proceedings:
Société Internationale de Chirurgie Orthopédique et de Traumatologie 284
American Academy for Cerebral Palsy 304
Western Orthopedic Association 309

David Stephen Grice 319

News Notes 321

Book Reviews 323

List of Advertisers ..... Adv. 53

Addresses of Contributors ..... Adv. 55

Subscription Rates for 1961

American Volume, $14.50
Published January, March, April, June, July, September, October, December

British Volume, $7.50
Published February, May, August, November

All subscription rates include postage.

Checks should be made payable to *The Journal of Bone and Joint Surgery, Inc.*

Microfilms of the American Volumes are available to regular subscribers through University Microfilms, 313 North First Street, Ann Arbor, Michigan

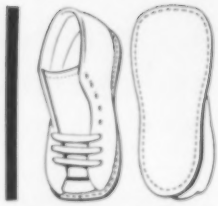
Although it is intended that all advertising material accepted conforms to ethical medical standards, acceptance does not imply endorsement by *The Journal.*

THE JOURNAL OF BONE AND JOINT SURGERY

American Office
8 The Fenway, Boston 15, Massachusetts, U. S. A.

British Office
82 Portland Place, London, W. 1, England

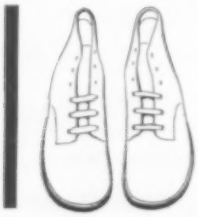
Look to the shoes



Pre-Walker, reverse or straight last

Pigeon-Toe, for mild supination

that have earned the



Super-Pedic, for extreme pronation

confidence of the

medical profession.

Prona-Pedic, for extreme supination

CorecTreds and

CorecTred, for mild pronation

Thomas Heel Extended Counter

Pedics by Edwards

For over 60 years Edwards has sought to develop a *complete line* of fully adaptable, quality shoes, at sensible prices, to meet doctors' special prescription requirements. Using tested lasts from clinic-approved patterns, Edwards experienced craftsmen developed CorecTreds and Pedics, the most versatile shoes available, sold by conscientious retailers trained in prescription fitting.

Whatever your prescription requirements, examine and advise CorecTreds and Pedics by Edwards!

Edwards
THE SHOE FOR CHILDREN
®

PHILADELPHIA 7, PA.

FREE EDWARDS NEW PEDIC KIT

Now, receive Edwards new, complete Pedic Kit designed especially for you. It contains:

- WEDGE CHART
- PEDICGRAPH
- PRESCRIPTION PADS
- CORECTRED FOLDERS
- PEDIC BROCHURES
- HAPPY FEET BOOKLET

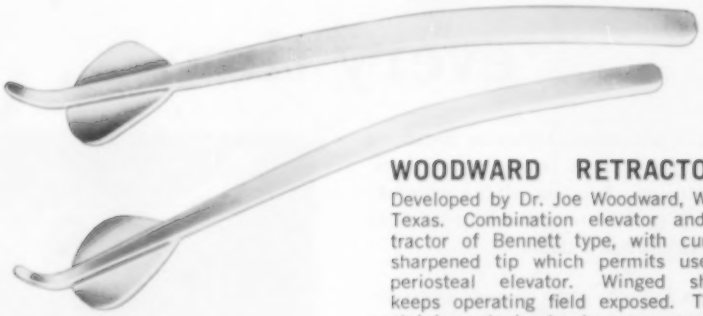
Simply Detach This Portion of Advertisement, Mail With Your Personal Letterhead to Edwards Shoes, 314 N. 12th St., Phila. 7, Pa.

De Puy

New Instruments to better serve you!

MENISCUS KNIFE

Developed by Drs. Ralph Soto-Hall and Keene Haldeman, San Francisco, this new instrument is used to cut posterior horn of the meniscus cartilage using an anterior incision. Simply hook opening in blade over posterior horn and turn knurled knob to obtain clean cutting action. Works much like a tonsil snare, but has advantage of sharp, spring steel blade which will not break, is easily sharpened or inexpensively replaced. Clinically tested and approved by leading orthopedic surgeons. No. 838C (Curved), shown, or No. 838S (Straight), $32.50. Extra blades, each, No. 838B, $1.50

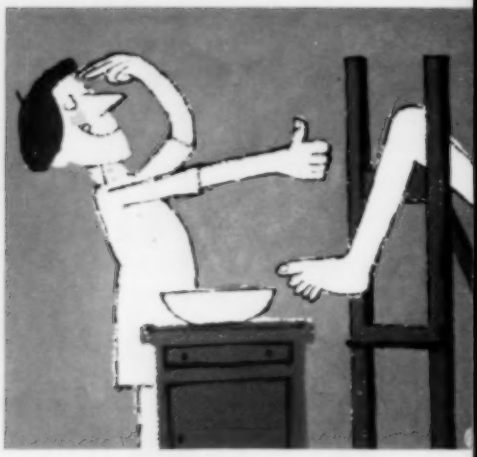


WOODWARD RETRACTORS

Developed by Dr. Joe Woodward, Waco, Texas. Combination elevator and retractor of Bennett type, with curved, sharpened tip which permits use as periosteal elevator. Winged shield keeps operating field exposed. These stainless steel retractors are generally used in pairs. Nesting effect is obtained when retractors are used opposite each other with blade ends under the bone. Two sizes available — large for femur, humerus, etc., and small for radius, ulna and other small bones. No. 834L (Large), No. 834S (Small), $17.50 per pair.

Order now! Get our complete catalog.

DE PUY MANUFACTURING CO., INC., WARSAW, INDIANA



A true artist.....takes joy in his work.....

OSTIC helps you make strong, neat casts every time

Ostic is the all-around plaster bandage that's so popular in teaching centers. It's easy to use. Applies with a creaminess that's gentle to your hands. Sets quickly, takes hard use.

Nothing can take the place of professional experience when it comes to building a neat, strong cast. But a good part of your results can depend upon the plaster bandage you use. That's why so many specialists in orthopedic teaching centers use Ostic plaster bandages.

They know they can count on Ostic for consistently fine results. Ostic is fast. It's strong enough to take most any kind of wear. And Ostic delivers at least 97% of the original plaster to the cast. You can work with it all day long.

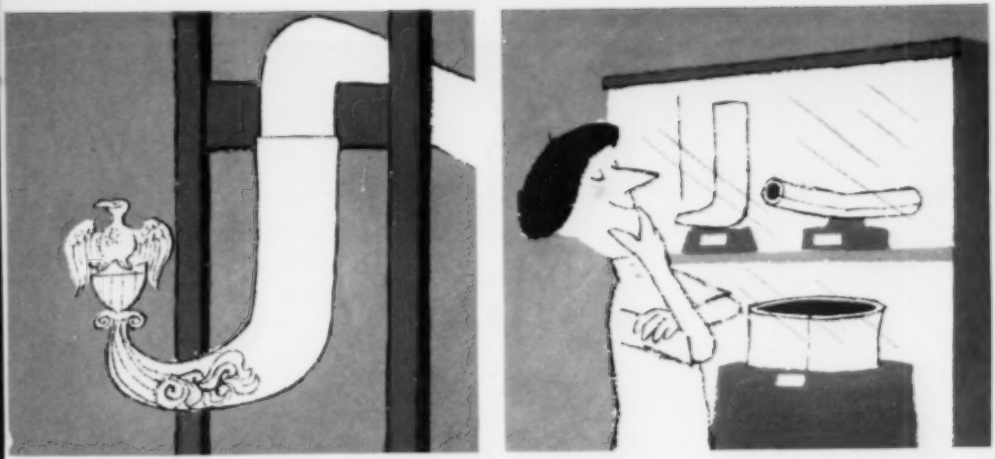
Each Ostic plaster bandage comes in its own airtight package. Plaster stays fresh indefinitely. Eliminates any danger of presetting.

Gentle creaminess of Ostic is never hard on your hands. You get a choice of two setting times: Fast (5 to 8 minutes) and Extra Fast (2 to 4 minutes). Call your Curity representative for the complete story of **OSTIC Plaster Bandages.**

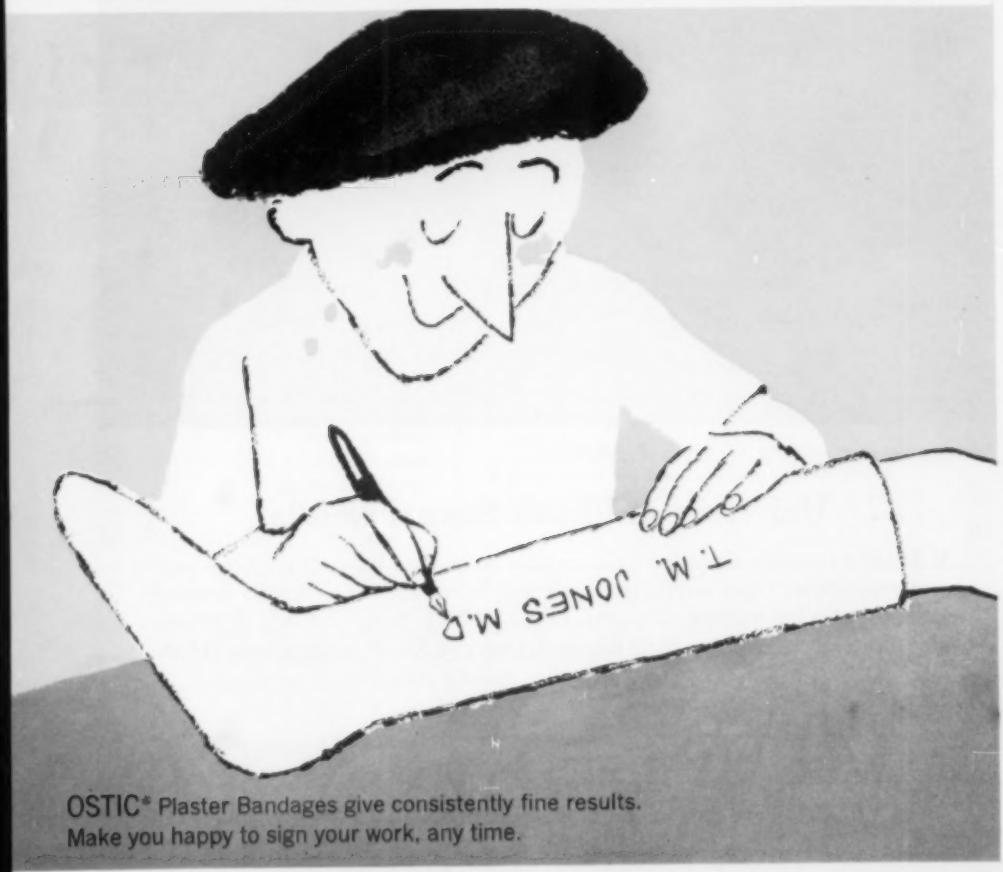
Curity®

THE KENDALL COMPANY
BAUER & BLACK DIVISION

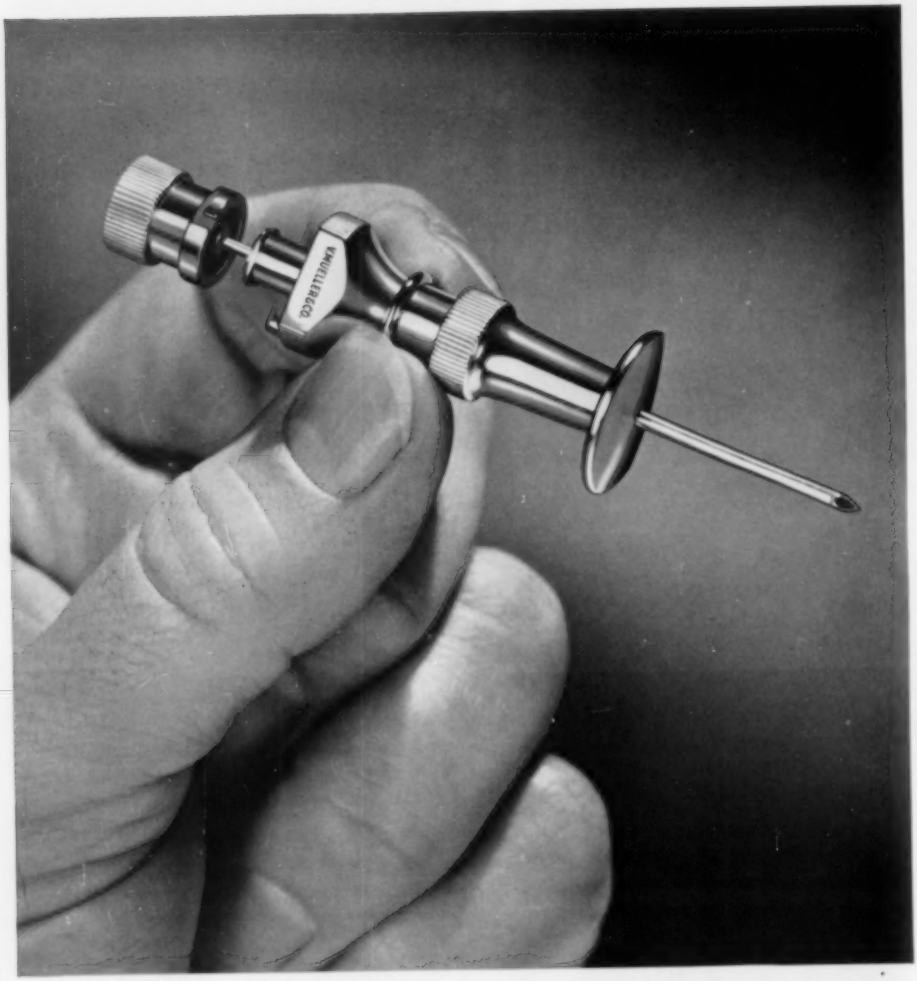
In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*



.....adds a touch of originality to each job.....enjoys looking at his masterpieces



OSTIC® Plaster Bandages give consistently fine results.
Make you happy to sign your work, any time.



to make the most of your talents and techniques . . .

University of Illinois Sternal Needle

V. Mueller research simplifies a dependable technique. Efficient for bone marrow aspirations from sternum, iliac crest, vertebra, tibia, femur, internal malleoli; also for marrow infusions. Depth of 15G, 1-inch cannula is adjustable; stylet locks in place. Stainless steel. Order as No. SU-21000, each $14.50.

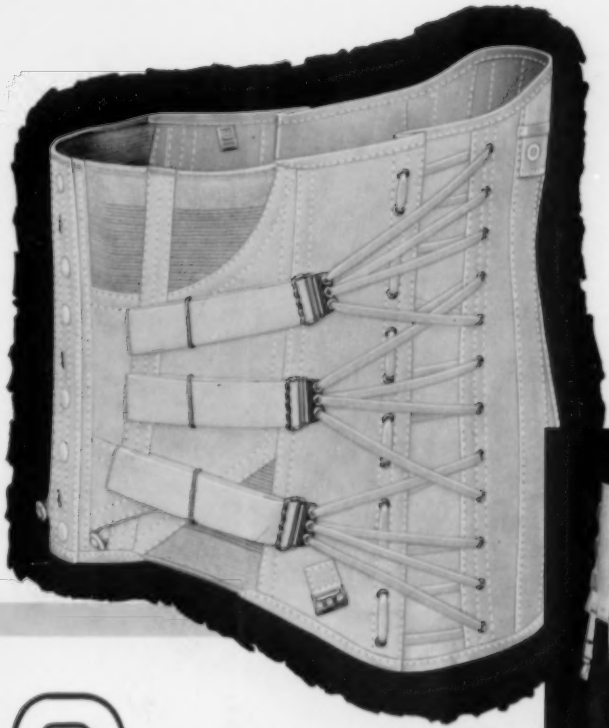
VMUELLER & CO.

Fine Surgical Instruments and Hospital Equipment Since 1895

330 S. Honore Street, Chicago 12, Illinois

Dallas • Houston • Los Angeles • Miami, Fla. • Rochester, Minn.

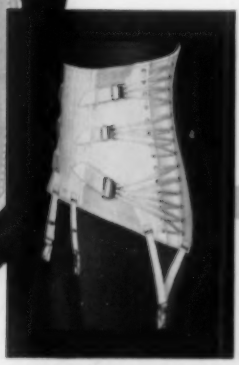
In answering advertisements, please mention *The Journal of Bone and Joint Surgery*.



DEEP BACK SACRO-LUMBAR SUPPORT BY TRUFORM.

Men's Model 445-EHS (left) has 4 removable steel back stays.

Women's Model 1107-HS (below) has 2 steel stays.



3 SETS OF PULL STRAPS PROVIDE RIGID SUPPORT

A great degree of rigidity can be secured with the deep-front sacro-lumbar garment pictured above . . .

- Removable semi-rigid stays in the back control antero-posterior flexion.
- 3 sets of pull straps operate through the side lacing to control traction.
- Deep front for greater rigidity, elastic top and bottom gussets for more comfort.

Always rely on Truform supports that are anatomically correct and therapeutically sound. Rely, too, on fitting by expertly trained and skilled technicians. Prescribe *Truform anatomical supports* with confidence . . . available to you and your patients only from the Ethical Appliance Dealer.

TRUFORM

anatomical supports

3961 Rosslyn Drive, Cincinnati 9, Ohio

Branches: New York and San Francisco

In answering advertisements, please mention *The Journal of Bone and Joint Surgery*.

New, more effective analgesic

Kills pain

stops tension

For neuralgias, dysmenorrhea, upper respiratory distress, and postsurgical conditions... new compound kills pain, stops tension, reduces fever—gives more complete relief than other analgesics.

Soma Compound is an entirely new, totally different analgesic combination that contains three drugs. First, Soma: a new type of analgesic that has proved to be highly effective in relieving both pain and tension.* Second, phenacetin: a "standard" analgesic and antipyretic. Third, caffeine: a safe, mild stimulant for elevation of mood. As a result, the patient gets more complete relief than he does with other analgesics. Soma Compound is nonnarcotic and nonaddicting. It reduces pain perception without impairing the natural defense reflexes.*

NEW NONNARCOTIC ANALGESIC

soma® Compound

Composition: Soma (carisoprodol), 200 mg.; phenacetin, 160 mg.; caffeine, 32 mg.
Dosage: 1 or 2 tablets q.i.d.
Supplied: Bottles of 50 apricot-colored, scored tablets.

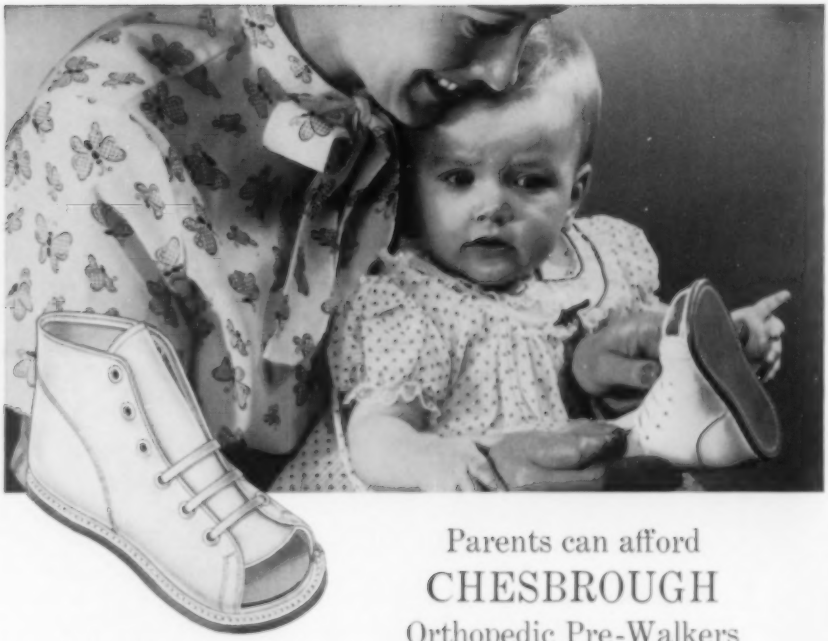
NEW FOR MORE SEVERE PAIN

soma® Compound + codeine

BOOSTS THE EFFECTIVENESS OF CODEINE: Soma Compound boosts the effectiveness of codeine. Therefore, only ¼ grain of codeine phosphate is supplied to relieve the more severe pain that usually requires ½ grain. **Composition:** Same as Soma Compound plus ¼ grain codeine phosphate. **Dosage:** 1 or 2 tablets q.i.d. **Supplied:** Bottles of 50 white, lozenge-shaped tablets; subject to Federal Narcotics Regulations.

References available on request.

WALLACE LABORATORIES · Cranbury, N. J.



Parents can afford
CHESBROUGH
Orthopedic Pre-Walkers

No. 1400 OPEN TOE
Straight-line symmetrical last, firm heel, no back seam. Adaptable to Denis Browne Splints.

No. 1300 CLOSED TOE
Lace-to-toe design permits snug, gentle fit. Perfectly smooth inside.

No. 1700 CLUBFOOT, OPEN TOE
Special outflare last, sturdy instep strap to stabilize heel.

Louis C. Weld, President of G. W. Chesbrough Co. . . . "My own personal experience led to the development of the new Chesbrough Shoe."

Here are Orthopedic infants' shoes that meet rigid requirements of corrective footwear yet fit the family budget.

High-quality workmanship and fine leathers with orthopedically correct lasts are combined in Chesbrough Shoes to sell at a moderate price.

Any parent whose child requires orthopedic correction knows the expense is great, as frequent purchase of new shoes is required.

This problem was brought home to Chesbrough's president, Louis C. Weld, three years ago, when a child in his own family needed such a shoe. Recognizing the need for orthopedic shoes at an economical price, Chesbrough Company put their 60 years of shoemaking experience to work and Chesbrough Corrective Pre-Walker Shoes were born.

All shoes in unlined white elk, sizes 000 to 4, narrow and wide. Available in full pairs, split pairs or single shoes (no extra charge for half pairs).

MAIL COUPON FOR FREE DESK SAMPLES

G. W. CHESBROUGH CO.
807 Smith Street, Rochester 6, N. Y.

NAME .....

ADDRESS .....

CITY ..... STATE .....

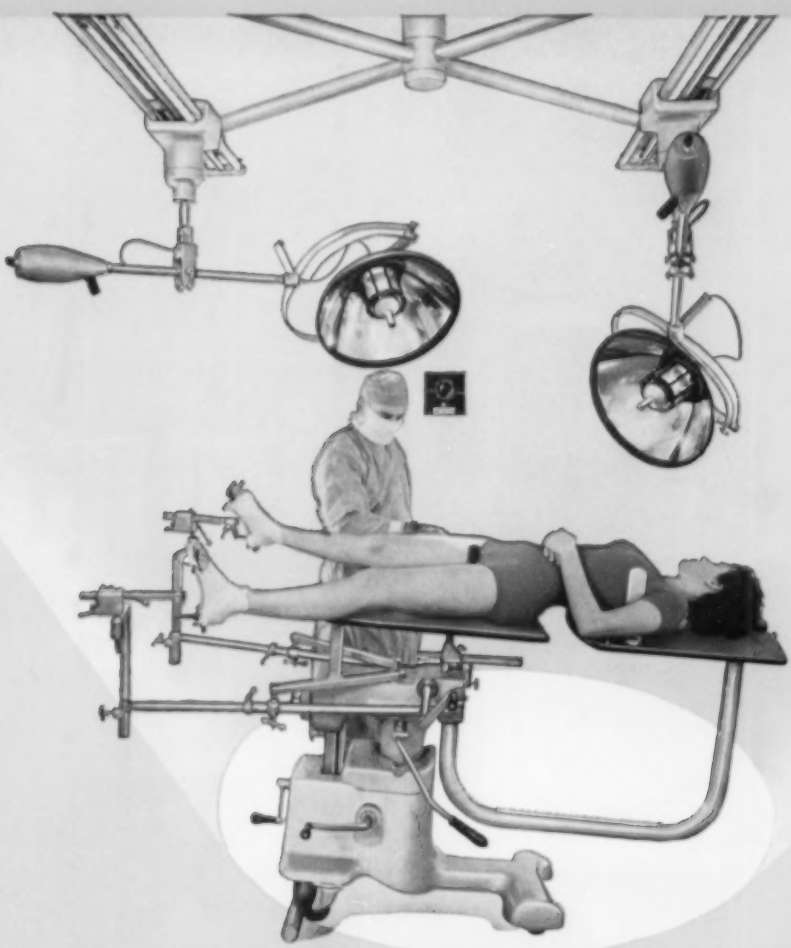
YOUR ORTHOPEDIC SHOE DEALER

.....

Precise Positioning and Positive Fixation—

with AMERICAN-Albee

ORTHOPAEDIC *and* FRACTURE TABLE



● Acknowledged as the most versatile in its field, the American-Albee Orthopaedic and Fracture Table enables the orthopaedic surgeon to achieve "perfect positioning" of short, tall, obese and even infant patients . . . easily and rapidly. It is designed to accommodate closed fracture reductions as well as the increasing demands of complex orthopaedic surgery. Thus, to orthopaedists the world over, the name American-Albee identifies the table of choice for this comprehensive branch of medicine.

Ideal complement to this improved table is the American DV-22 Major Surgical Light . . . a new concept in easily maneuverable illumination . . . cool, shadowless, color-corrected . . . intensity to 10,000 foot candles *from a dual source.*

● *Write for Fracture Table Brochure TC-100R and Major Light Catalog LC-121R.*

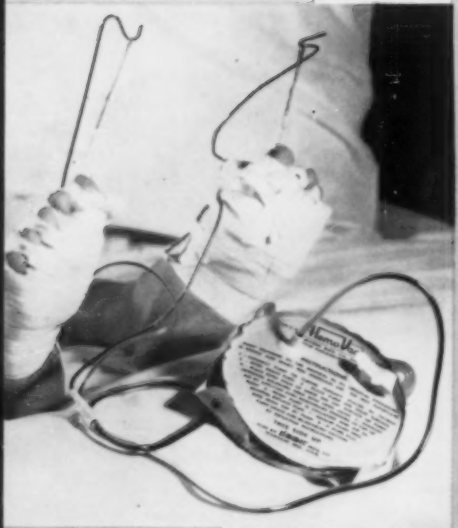
AMERICAN STERILIZER

ERIE • PENNSYLVANIA

No post-amputation fever. Minimal pain. Nice primary wound healing.

No visible stain even 40 hours after operation.

HemoVac kept wound clean, flat and free of seepage.



zimmer®

Keller procedure (bunion) With Y connector, Evacuator handles both wounds.

First day after bone graft. Note lack of swelling around toes.

Easily portable unit allows earlier ambulation.

HemoVac closed suction aids in completing successful surgery

PAT. PENDING

Improves and speeds healing by gently pulling wound tissue together by suction . . . draws excess fluids and dead cells completely out of the wound area. May be applied for irrigation or closed circulation of anti-biotics to treat osteomyelitis and potentially infected wounds.

HemoVac goes to work as soon as deep fascia has been closed . . . continues without interruption, even while patient is transferred to recovery room. Completely portable and disposable.

THE HEMOVAC PRINCIPLE

is simple and logical. The multi-perforated section of non-pyrogenic plastic tubing (⅛" diameter) is laid in the wound at the point(s) where blood and lymphatic fluids are prone to collect and led out through sound tissue away from the wound area. After proper wound closing the HemoVac Spring Evacuator Pump maintains a constant and gentle suction, removing excess fluids and drawing separated tissues together for faster healing. Thus all wound tissue is permitted to heal more rapidly and naturally.

Write for new illustrated brochure

zimmer®

Developed and manufactured by Snyder Mfg. Co., Inc., New Philadelphia, Ohio

Distributed exclusively by Zimmer Manufacturing Co., Warsaw, Indiana, U.S.A.

QUALITY • SERVICE • RESEARCH

Aireloom INVENTS A NEW MATTRESS THAT NEEDS NO BUILT-IN BEDBOARDS

VITAGENIC—the prescription-built extra-firm mattress eliminates the need for old-fashioned built-in bedboards. That's because VITAGENIC is made right! Many mattresses are structurally weak, basically inadequate and require the addition of a makeshift board to strengthen them. VITAGENIC stands alone as the first *true* therapeutic mattress for pain of backache or sacroiliac injury.

VITAGENIC—the prescription-built extra-firm mattress—*offers curled hair for resilient firmness!* Your patients get the benefit of firm body support without undue stress on nerve points or interference with circulation. VITAGENIC also guarantees *hand-stitched sidewalls that do not sag!* Your patients are able to get in and out of bed with less effort and greater stability because VITAGENIC's sag-free sidewalls allow no "give" that might upset your patient's equilibrium. This means *12% more usable sleeping surface* and is only achieved by meticulous hand-stitching.

VITAGENIC—the prescription-built extra-firm mattress, is a mattress and box spring combination made *exactly* to the specifications of registered orthopedic specialists. With VITAGENIC, there can be no doubt your patient is resting correctly and comfortably. *You* prescribe the optimum degree of firmness necessary as well as other features important for your patient's treatment.

THE VITAGENIC IS GUARANTEED IN WRITING FOR FIFTEEN YEARS!

For full details on the extra-firm prescription-built VITAGENIC, contact

Aireloom **BEDDING COMPANY**

1119 Westminster Avenue, Alhambra, California

created by King Karpen — established 1951

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

STRUCTURALLY SOUND

SMo

TYPE 316

NEUFELD FEMORAL NAIL PLATES

have been engineered to provide maximum strength at the bend. Available in either Neutrilium (cobalt alloy) or type 316 stainless steel with screws of identical metals . . . The Neufeld nail is the choice of careful, discriminating orthopedic surgeons.

Ask your Surgical Supply Dealer or
write for additional technical information

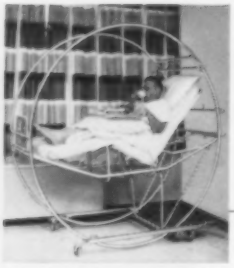
MEDICAL RESEARCH SPECIALTIES
Loma Linda, California

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

Reprints suitable for framing available upon request.

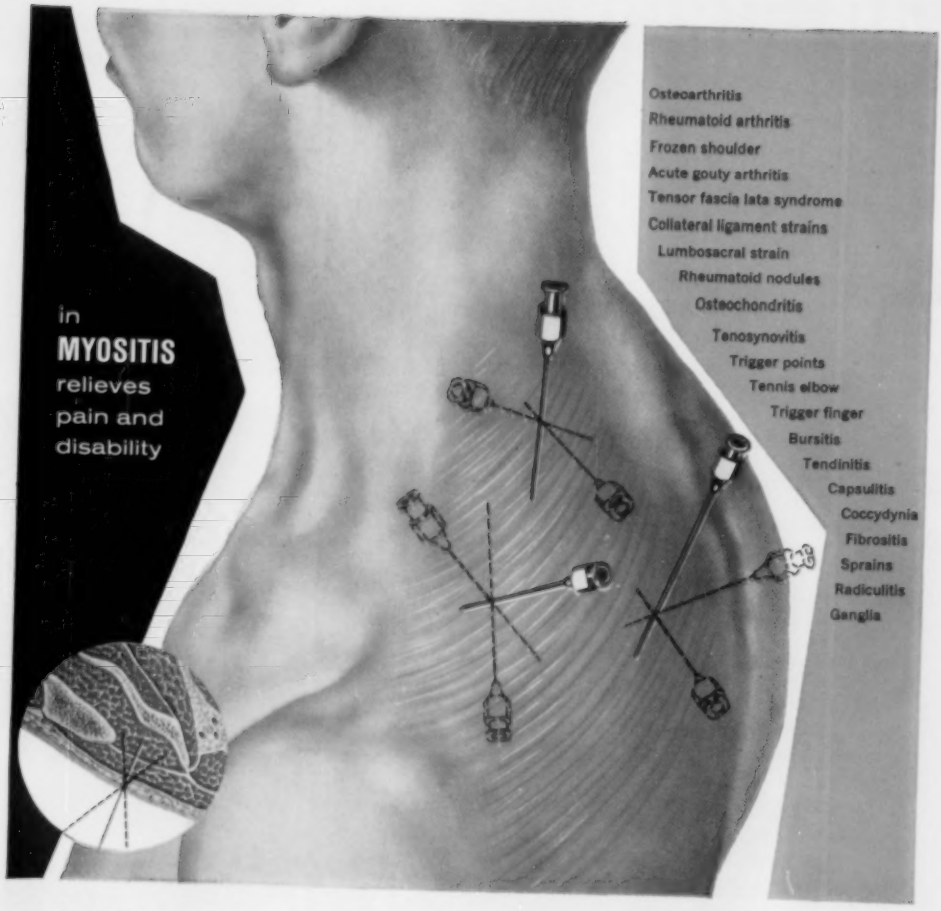
Today's concept in patient handling...

Stryker CIRCOLECTRIC
UNIVERSAL HOSPITAL BED



With the CircOlectric the patient can position himself, or be positioned easily for his own comfort, for nursing care, or as clinically indicated – at the flick of a button. Any patient you lift, turn, or transfer to and from bed can be better handled on the CircOlectric. Should be used for all orthopedic cases, neurosurgery, cardiovascular diseases, burns and general surgery. Write for complete information or ask for one on 30 day approval.

Stryker
SURGICAL AND HOSPITAL EQUIPMENT
Orthopedic Frame Company
420 ALCOTT STREET • KALAMAZOO, MICHIGAN



SUSPENSION

HYDELTRA-T.B.A.®

PREDNISOLONE TERTIARY-BUTYLACETATE

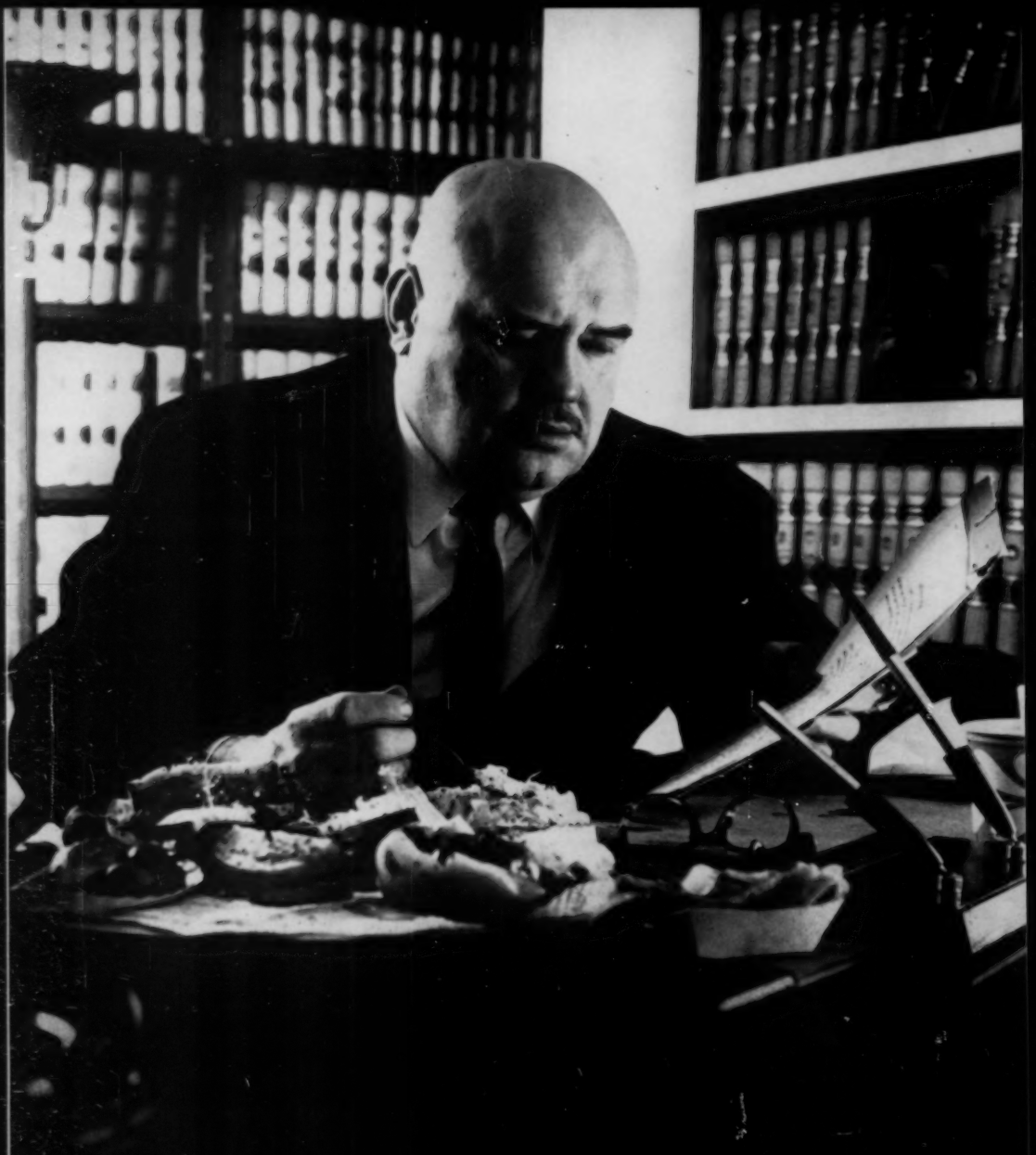
CONSISTENTLY EFFECTIVE—PROLONGED RELIEF

Dosage: the usual intra-articular, intrabursal or soft tissue dose ranges from 20 to 30 mg. depending on location and extent of pathology.

Supplied: Suspension HYDELTRA-T.B.A.—20 mg./cc. of prednisolone tertiary-butylacetate in 5-cc. vials.

Additional information is available to physicians on request. HYDELTRA-T.B.A. is a trademark of Merck & Co., INC.

MSD MERCK SHARP & DOHME
Division of Merck & Co., Inc., West Point, Pa.



for "special-problem" patients...when corticosteroid therapy is indicated

Aristocort

in rheumatoid arthritis

Aristocort®

Triamcinolone LEDERLE

UNSURPASSED "GENERAL-PURPOSE" STEROID
OUTSTANDING FOR "SPECIAL-PURPOSE" THERAPY

ARISTOCORT Triamcinolone has long since proved its *unsurpassed efficacy and relative safety* in treating rheumatoid arthritis. Mounting clinical evidence has shown that ARISTOCORT is also highly valuable for the "special-problem" arthritic—the patient who, because of certain complications, was hitherto considered a poor candidate for corticosteroids.

for example:

SPECIAL PROBLEM: ANXIETY-TENSION

When triamcinolone was used, euphoria and psychic unrest rarely occurred. (McGavack, T. H.: *Clin. Med.* 6:997 [June] 1959.)

SPECIAL PROBLEM: OVERWEIGHT

No patient developed voracious appetite on triamcinolone. Preferable for the overweight person whose appetite is undesirably stimulated by other steroids. (Freyberg, R. H.; Berntsen, C. A., Jr., and Hellman, L.: *Arthritis & Rheumatism* 1:215 [June] 1958.)

SPECIAL PROBLEM: EDEMA

Since it does not produce edema, triamcinolone is useful in rheumatoid arthritis patients with cardiac decompensation who need steroid therapy. (Hollander, J. L.: *J.A.M.A.* 172:306 [Jan. 23] 1960.)

SPECIAL PROBLEM: HYPERTENSION

Triamcinolone may be included among the currently available antirheumatic steroids having the least tendency to cause sodium retention. (Ward, L. E.: *J.A.M.A.* 170:1318 [July 11] 1959.)

Hypertension did not result from triamcinolone therapy. Existing hypertension was reduced sometimes. This may have been due to lack of sodium retention. (Freyberg, R. H.; Berntsen, C. A., Jr., and Hellman, L.: *Arthritis & Rheumatism* 1:215 [June] 1958.)

Precautions: Collateral hormonal effects generally associated with corticosteroids may be induced. These include Cushingoid manifestations and muscle weakness. However, sodium and potassium retention, edema, weight gain, psychic aberration and hypertension are exceedingly rare. In the treatment of rheumatoid arthritis, dosage should be individualized and kept at the lowest level needed to control symptoms. Dosage should not exceed 36 mg. daily without potassium supplementation. Drug should not be withdrawn abruptly. Contraindicated in herpes simplex and chicken pox.

Supplied: Scored tablets — 1 mg. (yellow); 2 mg. (pink); 4 mg. (white); 16 mg. (white). Also available — syrup, parenteral and various topical forms.

Lederle

LEDERLE LABORATORIES, A Division of AMERICAN CYANAMID COMPANY, Pearl River, N.Y.

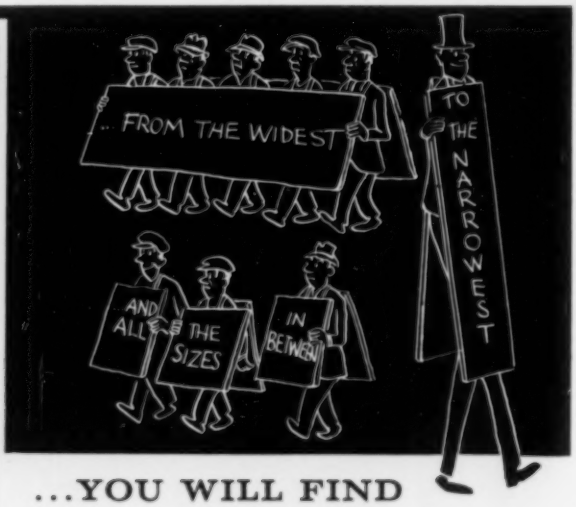
In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

STRAIGHT LAST

REGULAR

ARCH FEATURE

MISMATES



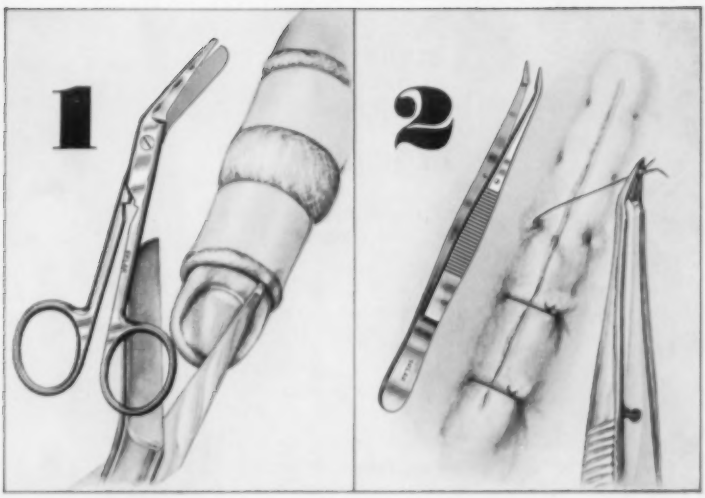
...YOU WILL FIND EVERYTHING YOU WANT AND NEED IN

Child Life SHOES

A complete line of children's shoes that adapt themselves readily to your corrective prescription . . . yet every shoe is styled to look like a "regular shoe." There is a specially selected CHILD LIFE dealer in your community who is competent to handle your instructions.

Write for his name, and for the CHILD LIFE service booklet for the professional man, featuring representative shoes and wedging procedures.

HERBST SHOE MANUFACTURING COMPANY
Box 2005 Milwaukee 1, Wisconsin



specifically designed for the purpose

1 Burnham Finger Bandage Scissors

Minimizes pain caused by conventional acorn tip ...thin lower blade with rounded tip slips easily under bandage... notched shank facilitates ready removal of needles frozen to syringes...provides leverage to shear through heavy dressings —yet compact and light enough for the pocket.

Healy Suture Removing Forceps 2

Superior to anatomic forceps for suture removal... broad triangular shaped jaws... roughened inner surfaces grip and hold the suture for cutting...precisely aligned, pointed tips permit gentle teasing out of suture ends that have retracted under the skin or become encrusted with exudate.

SKLAR PRODUCTS

Both instruments precision made of stainless steel by SKLAR, Long Island City, N.Y.

Available through accredited surgical supply dealers.

. . . THEY CAN WALK AGAIN

Torpedoed on the Murmansk run—nearly frozen to death in an open boat—both legs lost below the knee—ex-Merchant Marines Michael McCormick and William Morris walked unaided in three weeks. They could look forward with certainty to leading a normal life again. To these men, as to thousands of other Hanger wearers, the phrase "Hanger is a symbol of help and hope" is a concrete truth proven by every day of their future lives.

Hanger PROSTHETICS

AVAILABLE AT AUTHORIZED FACILITIES IN THE FOLLOWING CITIES:

Eastern Region:
Baltimore 1, Md.
Boston 15, Mass.
Charleston 1, W. Va.
New York 11, N. Y.
Philadelphia 7, Pa.
Raleigh, N. C.
Richmond 19, Va.
Roanoke 12, Va.
Washington 13, D. C.

Midwestern Region:
Chicago 5, Ill.
Cincinnati 29, Ohio
Dallas 1, Texas
Evansville, Ind.
Fort Wayne, Ind.
Indianapolis 2, Ind.
Oklahoma City 3, Okla.
Peoria 4, Ill.
St. Louis 66, Mo.

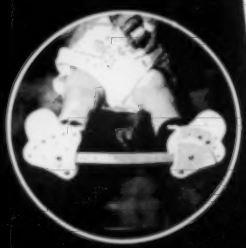
Central Region:
Columbus 8, Ohio
Pittsburgh 1, Pa.

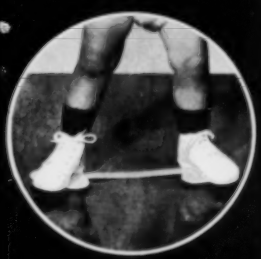
Southeastern Region:
Atlanta 9, Ga.
Birmingham 1, Ala.
Columbia 1, S. C.
Jacksonville, Fla.
Lafayette, La.
Miami 37, Fla.
Mobile, Ala.
Montgomery, Ala.
Nashville 5, Tenn.
New Orleans 19, La.
Orlando, Fla.
Savannah, Ga.
St. Petersburg, Fla.
Tampa 2, Fla.
West Palm Beach, Fla.

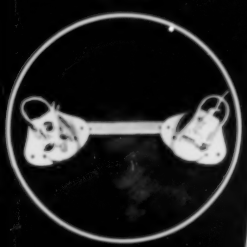
T&G

ORTHO-AIDE SPLINT

- UNIQUE ESTHETIC APPEAL
- FLAT BOTTOMS
- LIGHTWEIGHT







- SMOOTH PLASTIC SURFACES — Interchangeable, tough, plastic platforms feature smooth, sweeping, polished contours. They slide on the crossbar in either inversion or eversion orientation, maintaining shoes in 15° increments from 0° to 75°. The smooth bottoms are devoid of sharp projections that otherwise prevent the patient from standing and tend to catch on rugs, clothes, and bedding.
- ADJUSTABLE ALUMINUM CROSSBAR — Threaded in ½ inch increments, the adjustable crossbar permits on-the-spot heel-to-heel span adjustments.
- POSITIVE SHOE FASTENING — Three strategically placed, threaded, "tee-nut" rivets firmly secure the shoes — regardless of type or size of shoe. In addition, the shoes can be easily removed by the parent.
- SIMPLE ADJUSTABILITY — Of removable stainless steel machine screws combine the functions of orientating and setting the splint. This way any adult can make adjustments with a facsimile of a screwdriver. Furthermore, the adjustments are inaccessible to even the most astute patients.

NEW AND PRACTICAL CONCEPTS

DIRECT PRESCRIPTION ORDER SERVICE is an exclusive feature pioneered with the Ortho-Aide Splint. Using the handy Ortho-Aide Prescription-Order Card, the physician can order new shoes with the splint, pre-mounted to prescription, or, as a basic splint to which shoes may be mounted; thereby obviating many of the inconveniences and costs previously encountered by parents. Individual prescription-orders are filled within 24 hours of receipt.

FAVORABLE PARENTAL REACTION to the Ortho-Aide Splint is enjoyed by the physician; thanks to the judicious combination of rugged plastic and aluminum offering a refreshingly lightweight, toy-like outward appearance.

UNIVERSAL APPLICATION to the individual requirements of urban and rural physicians is attained by wide range of adjustment, ease of shoe mounting, and availability of the Ortho-Aide Splint through immediate, direct prescription ordering.

Write for your supply of the exclusive ORTHO-AIDE Prescription-Order Cards

WALLACE ORTHOPEDIC MANUFACTURING CO.
742 East Hyde Park Boulevard Inglewood 3 California

T+G

Put your low-back patient back on the payroll

Soma relieves stiffness —stops pain, too

YOUR CONCERN: Rapid relief from pain for your patient. Get him back to his normal activity, *fast!*

HOW SOMA HELPS: Soma provides direct pain relief while it relaxes muscle spasm.

YOUR RESULTS: With pain relieved, stiffness gone, your patient is soon restored to full activity—often in days instead of weeks.

Kestler reports in controlled study: *Average time for restoring patients to full activity: with Soma, 11.5 days; without Soma, 41 days.* (*J.A.M.A. Vol. 172, No. 18, April 30, 1960.*)

Soma is notably safe. Side effects are rare. Drowsiness may occur, but usually only in higher dosages. Soma is available in 350 mg. tablets. USUAL DOSAGE: 1 TABLET Q.I.D.

The muscle relaxant with an independent pain-relieving action

SOMA®

(*carisoprodol, Wallace*)

Wallace Laboratories, Cranbury, New Jersey

Put new spring in your step

* TM Ripple Sole Corp.

Genuine

*RIPPLE® Sole SHOES

The SURGEON
Tie-style, arch counter.
$21.95** ppd.

The NURSE
Tie-style, arch counter.
$20.95** ppd.

Here's good news for those who stand or walk long hours on their feet . . . a new, super-flexible "footing", RIPPLE® Sole, called in an article in Reader's Digest: "the most important improvement in footwear since Julius Caesar put heels on the boots of his legionnaires".

A series of flexible corrugations that depress when stepped on, then spring back to put pep in your step, RIPPLE® Sole has been tested and proven to help absorb shock, cause of most foot fatigue. Many doctors and nurses wear them, "live" in them. Try a pair yourself. Take a few steps. You'll never wear a more comfortable shoe. Satisfaction guaranteed. ORDER TODAY (give size, width) or write for FREE folder (smart styles for the whole family). **Mich. orders add 4% tax. (Men's, over size 12, add $1.50; women's over 10, add $1.) Conductive plug and heel seat, $3 extra.

Let shock-absorbing RIPPLE® Sole shoes ease every step for your patients as well. Remember . . . for perfection of fit . . . they can count on the Hack Shoe Co.'s 45 year reputation . . . and because only the finest-fitting footwear has ever carried a Hack label, you can recommend them with confidence.

THE HACK SHOE COMPANY, 5040 Mutual Building, Detroit 26, Michigan

---

Please send me ☐ **Technical information on RIPPLE® Sole** ☐ **Free style folder** ☐ **NURSE** ☐ **SURGEON**
Size....Width....

NAME.....

ADDRESS.....

CITY..... **ZONE**..... **STATE**.....

In answering advertisements, please mention *The Journal of Bone and Joint Surgery*.

CAMP

BRACES

anatomically
designed to help
provide therapeutic
immobilization
where desired

Prefabricated Braces

Easily shaped, lightweight aluminum Knight Spinal and Taylor braces offer effective and limiting movement in the region of the lower lumbar spine. Inside padding is blanket material covered with soft horsehide; outside is white sturanhyde plastic. Detachable straps; choice of pad or adjustable side lacing garment belt front. Hose supporters and/or perineal straps.

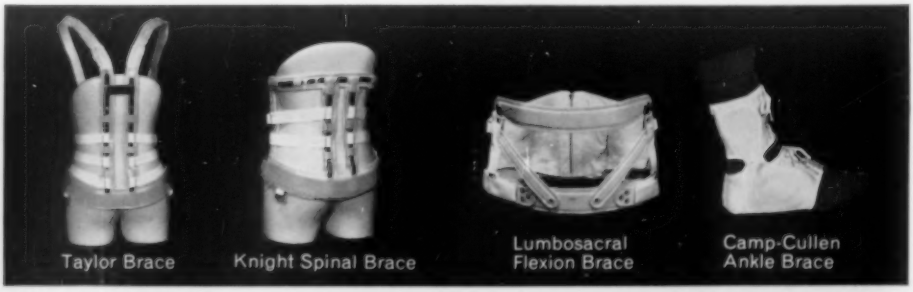
Lumbosacral Flexion Brace

This brace is designed to exert a constant corrective force on the lumbar spine, lumbosacral joint and pelvis to help overcome any excessive lordotic lumbar curve. It permits free lumbar spine flexion but prevents extension and lateral bending. There are three points of pressure: the lower thoracic spine, the sacrum and lower abdomen. Fashioned abdominal belt is attached to the side bars. Zipper front closing.

Camp Cullen Ankle Brace*

This unique brace allows free flexion and extension; resists inversion as well as eversion besides giving additional security by controlling adduction and abduction rotational strains on the foot. Fits without discomfort. Front lacing for care in donning or removing.

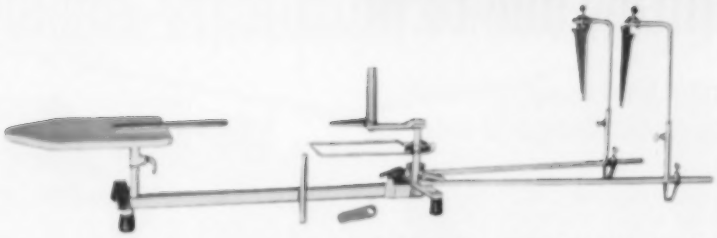
*Pat. Pend.



S.H. Camp and Company, Jackson, Michigan
S.H. Camp and Company of Canada, Ltd., Trenton, Ontario

CAMP

Fracture Tables for every purpose by . . . ORTHO-TRAC



MODEL 1000 ORTHO-TRAC INFANTS' AND CHILDREN'S CAST TABLE

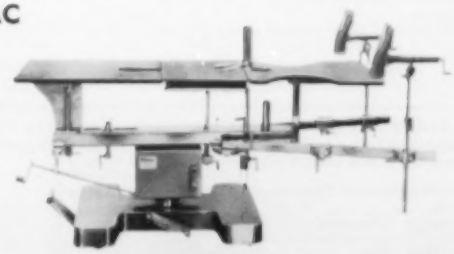
The first complete infants' and children's cast table that allows any type of cast to be applied to infants and children from one day to fifteen years. X-Ray work can be efficiently done. May be used any place in the hospital.

MODEL 2000 ORTHO-TRAC CAST AND X-RAY TABLE

The first real advance in cast tables in years. A simple, efficient, rugged, cast table on which any cast can be applied as well as the nailing of hips.

MODEL 3000 ORTHO-TRAC ORTHOPEDIC AND SURGICAL TABLE

The first foot hydraulic controlled combination orthopedic and surgical table with stainless steel base, conductive table tops, and a cassette holder equipped for grids. The finest table ever designed and built.



WRITE FOR DETAILS:

EXCLUSIVE WORLD-WIDE DISTRIBUTORS OF ORTHO-TRAC HOSPITAL ORTHOPEDIC AND FRACTURE EQUIPMENT

ZACK ROGERS ASSOCIATES INC.

5 BROADWAY • EAST PATERSON, NEW JERSEY • SW 7-8800

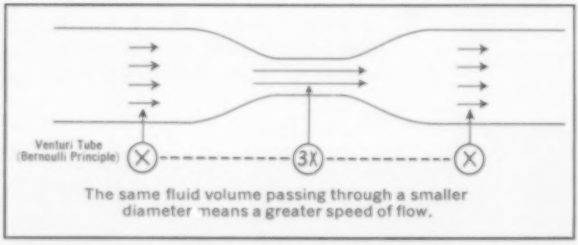
T.E.D. anti-embolism stockings speed blood flow, help reduce fatalities due to pulmonary embolism!

Accelerated blood velocity minimizes formation and incidence of clots

T.E.D. Anti-Embolism Stockings insure steady, uniform pressure of the lower leg, helping to speed the flow of blood.

It is reported that the majority of fatal pulmonary emboli cases originate with clots from the deep veins of the calf. T.E.D. Anti-Embolism Stockings counteract this by reducing the caliber of the veins enough to accelerate blood velocity and thus discourage thrombus formation.

T.E.D. Anti-Embolism Stockings maintain an over-all compression between 10 and 15 mm. of mercury—as you know, the ideal range in prophylaxis for thrombo-embolic disease. Application is so simple it can be handled even by a nurse's aid.



The same fluid volume passing through a smaller diameter means a greater speed of flow.

A constriction in a pipe increases the velocity of flow. The T.E.D. Anti-Embolism Stocking applies this principle, speeding the flow of blood in the lower leg where emboli most often get their start.

T.E.D.®
ANTI-EMBOLISM STOCKINGS
THE KENDALL COMPANY
BAUER & BLACK DIVISION

Recent Literature on Thrombosis and Pulmonary Embolism

1. Marino, D. J., and Fuchs, M.: Pathogenesis, Diagnosis, and Management of Thrombophlebitis, Geriat. 13:307 (May) 1958.
2. Houston, A. N., Roy, W. A., and Faust, R. A.: Thrombophlebitis of Superficial Abdominal Veins, J.A.M.A. 166:2158 (April 26) 1958.
3. Wilkins, R. W., Mixter, G., Jr.; Stanton, J. R., and Litter, J.: Elastic Stockings in the Prevention of Pulmonary Embolism, New England J. M. 246:360 (Mar. 6) 1952.
4. Judson, W. E.: Present Day Treatment of Congestive Heart Failure, The M. Clinics of N. America 35: 1333-1350 (Sept.) 1950.
5. Tidler, J.: Thrombo-Embolic Disorders, N. Carolina M. J. 18:65 (Feb.) 1957.
6. Allen, A. W.: Management of Thrombo-Embolic Disease in Surgical Patients, Surg., Gynec. and Obst. 96:107 (Jan.) 1953.
7. Foley, W. T., and Wright, I. S.: Medical Management of Thrombophlebitis, The Heart Bulletin 7:5 (Jan.-Feb.) 1958.
8. DeLaughter, G. D., Jr., Embolism, Pulmonary, in Conn., H. F., Current Therapy, Philadelphia, W. E. Saunders Co., 1958, P. 83.

FOR COMPLETE LITERATURE

on Thrombo-Embolic prophylaxis using T. E. D. Anti-Embolism Stockings, fill in and mail this coupon to:

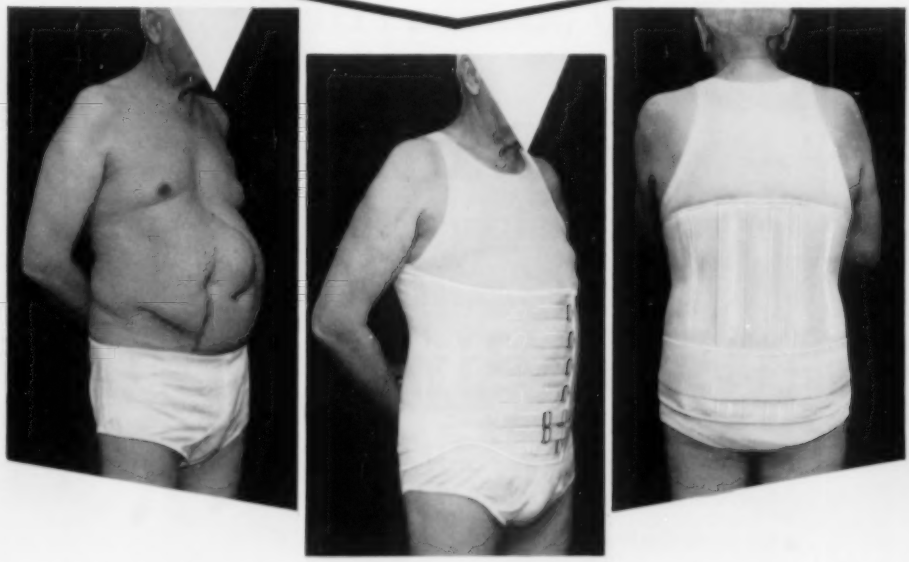
The Kendall Company
Bauer & Black Division,
Dept. BJS-3
309 W. Jackson Blvd., Chicago 6, Illinois

Name_____

Address_____

City_____ Zone____ State____

Spencer Scientifically Correlates Back And Abdominal Support to Meet the *Total Support Requirements* of This Patient



A Spencer Support was designed especially for this patient* — to immobilize the lumbar area, as part of conservative treatment to relieve acute symptoms of herniated intervertebral disc, and also to provide safe control of an inoperable abdominal hernia.

*Each Spencer Support is *individually designed* for the patient who is to wear it . . . and incorporates all of the features required by your prescription.

Spencer's Individual Designing Service is available to you through Corsetieres specially trained to help you help your patients.

SPENCER

individually designed supports for men, women and children

SPENCER, INCORPORATED

19 Ellsworth Ave., New Haven 7, Conn.

Canada: Spencer, Ltd., Rock Island, Quebec

England: Spencer, Ltd., Banbury, Oxon

☐ Send me the name of the nearest Spencer Corsetiere.

☐ I would like an office demonstration of Spencer benefits and features.

Name _____

Address _____

3-61

Proven

in over five years of clinical use and
more than 750 published clinical studies

Effective

for relief of anxiety and tension

Outstandingly Safe

- simple dosage schedule produces rapid, reliable tranquilization without unpredictable excitation
- no cumulative effects, thus no need for difficult dosage readjustments
- does not produce ataxia, change in appetite or libido
- does not produce depression, Parkinson-like symptoms, jaundice or agranulocytosis
- does not impair mental efficiency or normal behavior

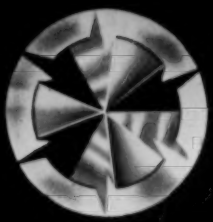
Miltown®

meprobamate (Wallace)

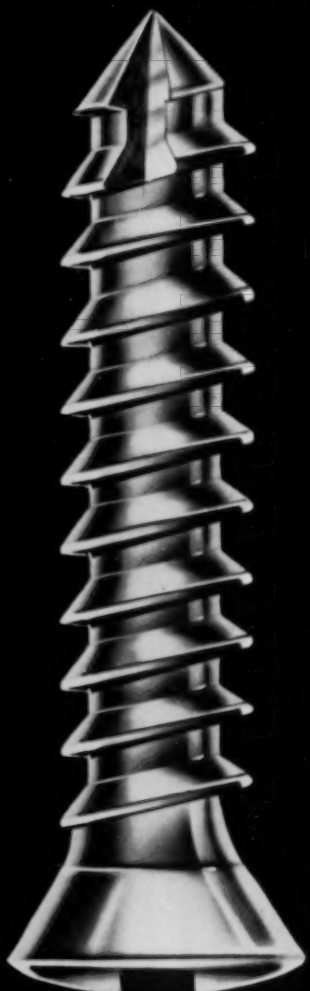
Usual dosage: One or two 400 mg. tablets t.i.d.
Supplied: 400 mg. scored tablets, 200 mg. sugar-coated tablets; or as MEPROTABS®—400 mg. *unmarked*, coated tablets.

WALLACE LABORATORIES / *Cranbury, N. J.*

®TRADE-MARK



Bechtol Radial Fluted Point



Cruciate Head uses standard screwdriver

NEW *Richards* BONE SCREW

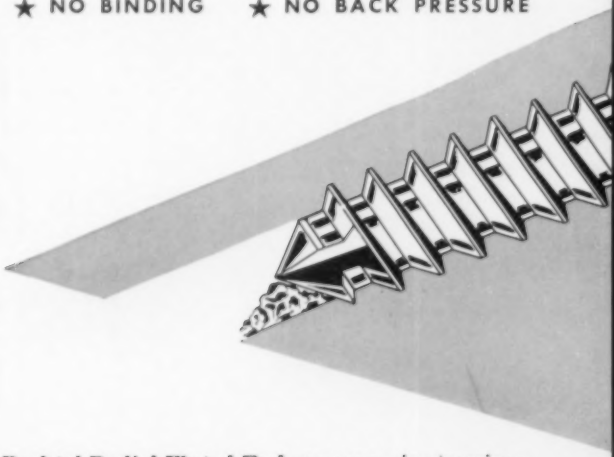
(SMO Stainless)

with Bechtol Radial Fluted Point

and buttress threads

★ TURNS EASIER ★ HOLDS BETTER

★ NO BINDING ★ NO BACK PRESSURE



Bechtol Radial Fluted End means easier turning because flutes move bone crumbs ahead, prevent them from clogging threads and causing screw to bind. Tests prove 50% less torque is required.

Buttress threads increase screw's holding power and eliminate back pressure.

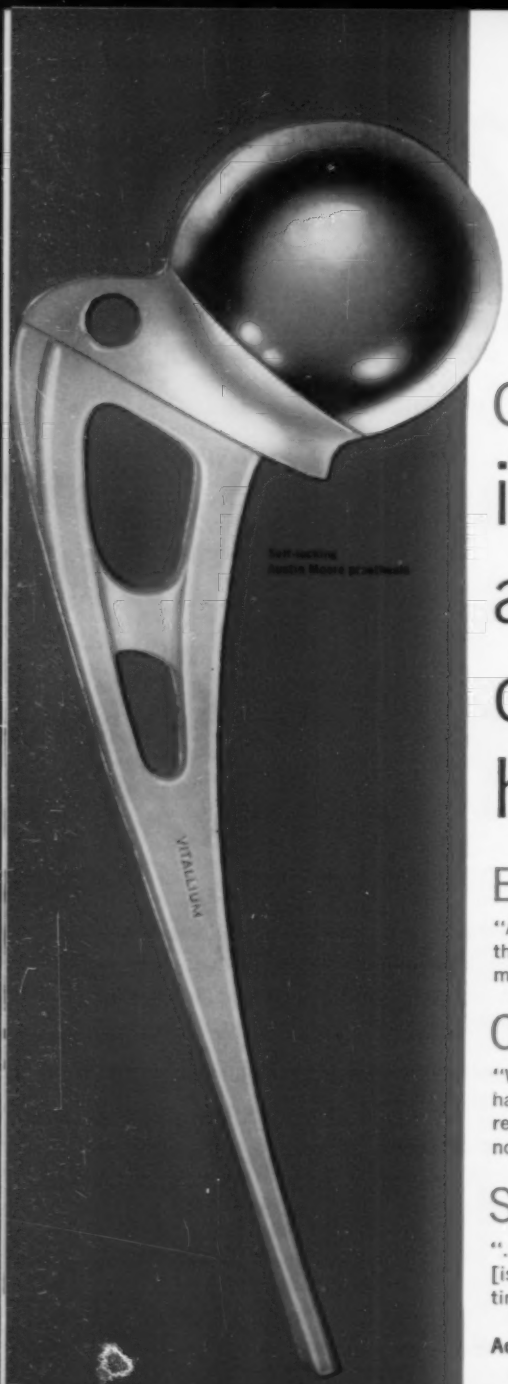
Micrometric accuracy in manufacture assures perfectly true shank for maximum ease of entry and greatest possible thread grip.

No special instruments needed. Precision-cut Cruciate Head requires standard screwdriver. Regular $\frac{7}{64}$" diameter drill bit used. Available in standard bone screw lengths.

Write for information.

Richards **MANUFACTURING COMPANY**

756 Madison Avenue, Memphis 3, Tennessee



3 vital considerations in relief of pain and restoration of function in hip pathology

Election of Arthroplasty

"Artificial prostheses for replacement of the upper end of the femur deserve a place in our armamentarium of treatment of hip disease."[1]

Choice of **Vitallium**®

"We believe that the cobalt-chrome alloys [VITALLIUM] have in clinical experience proved to be so superior in all respects to the existing stainless steels that they should now be very seriously considered for all surgical implants."[2]

Selection of Prosthesis

"... the Austin Moore intramedullary VITALLIUM prosthesis [is] one of the best prostheses available at the present time."[3]

Advantages of Hip Arthroplasty:

- Pain and disability relieved in most cases
- Shorter hospital stay; briefer convalescence period
- Less nursing care required
- Secondary surgical procedures unnecessary in virtually all cases
- Return to active, useful life

Indications for Hip Arthroplasty:

Osteoarthritis
Rheumatoid arthritis
Aseptic and avascular necrosis
Bilateral ankylosis
Salvage
Acute fractures in the aged
Un-united, long-term fractures
Delayed non-union
Acute unstable fracture (Pauwels' 3)
Pathologic fractures

For further information about VITALLIUM appliances, consult your surgical dealer or write to Austenal Company.

REFERENCES: 1. Coonsen, F.G.: Wisconsin Med. J. 59:181. 1960. 2. Scales, J. T., and Zarek, J.M.: J. Bone & Joint Surg. 37B:827. 1955. 3. Matchett, F.: Rocky Mountain M.J. 56:47. 1959. 4. Callahan, J.J.: S. Clin. North America, W.B. Saunders Co., Philadelphia, Feb. 1957, p. 135.

What is **Vitallium**®?

VITALLIUM is a registered trade-mark of the Austenal Company applied to certain cobalt-chromium alloys and to surgical appliances made from those alloys.

"[Its] unique suitability for surgical appliances derives from its inherent corrosive resistance, its compatibility with human tissues, its inertness and lack of electrolytic activity, together with its toughness and strength."[4]

Due to the toughness of the alloys, VITALLIUM appliances are not readily machined or worked by conventional methods. Special equipment designed by Austenal is used, thereby maintaining rigid specifications in all manufacturing procedures.

Twenty-five years of experience in machining and casting of VITALLIUM permits the versatile fabrication of many intricate designs necessary to conform to the anatomical requirements of the human skeletal structure.

Constant evaluation of raw materials, processes utilized, metallurgical knowledge and rigid inspection procedures insure the highest quality-control standards for surgeon-approved VITALLIUM products.

With over 9 million VITALLIUM surgical implants in use, not a single case of corrosion has been reported in the literature.

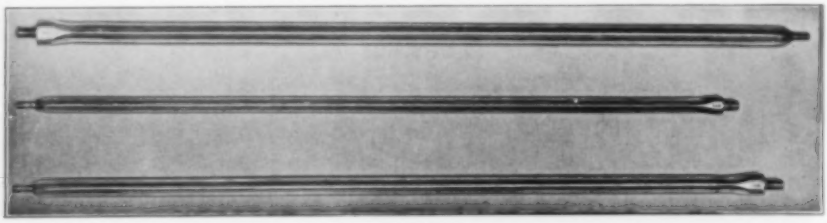
VITALLIUM®

Pioneered and Backed by Unmatched Experience in Surgical Alloys

AUSTENAL COMPANY SURGICAL PRODUCTS

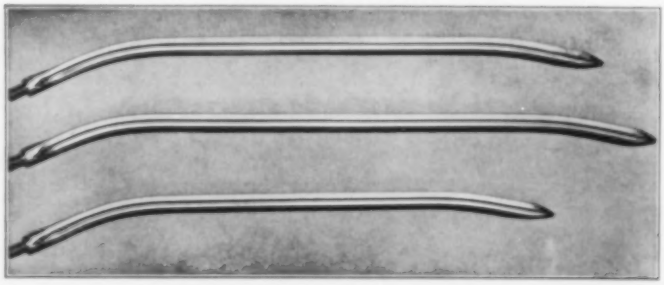
Division of Howe Sound Company • 370 East 36th Street, New York 16, N. Y.

LOTTES NAILS and INSTRUMENTS

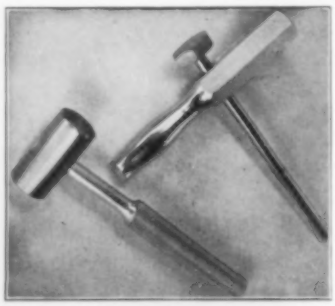


***LOTTES* FEMORAL NAILS** are manufactured with diameters of **⅜, 7/16,** and **½** inches —with lengths in ½ inch variations from 14 to 20 inches.

***LOTTES* TIBIAL NAILS** are made in 5/16 and ⅜ inch diameters—in lengths from 9 to 15½ inches, in variation of ½ inch.



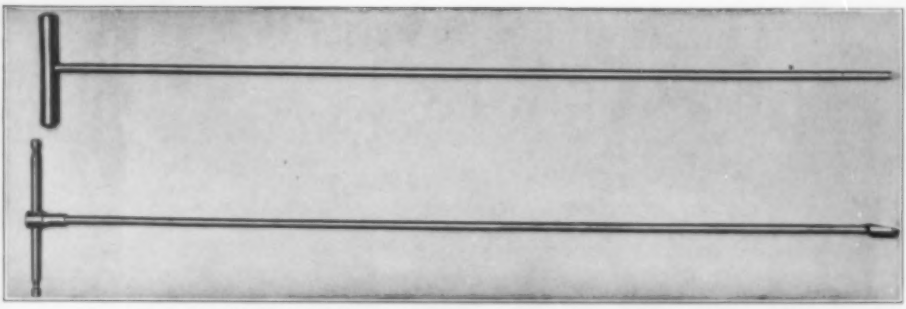
***LOTTES* NAILS AND INSTRUMENTS ARE MADE OF 18-8 SMo STAINLESS STEEL**



***LOTTES* DRIVER-EXTRACTOR COMBINATION and *LOTTES* MALLET**

***LOTTES* GUIDE WIRE AND *LOTTES* REAMER**

The reamer comes in 3 diameters: ⅜, 7/16, and ½ inch—all are 23 inches in length.

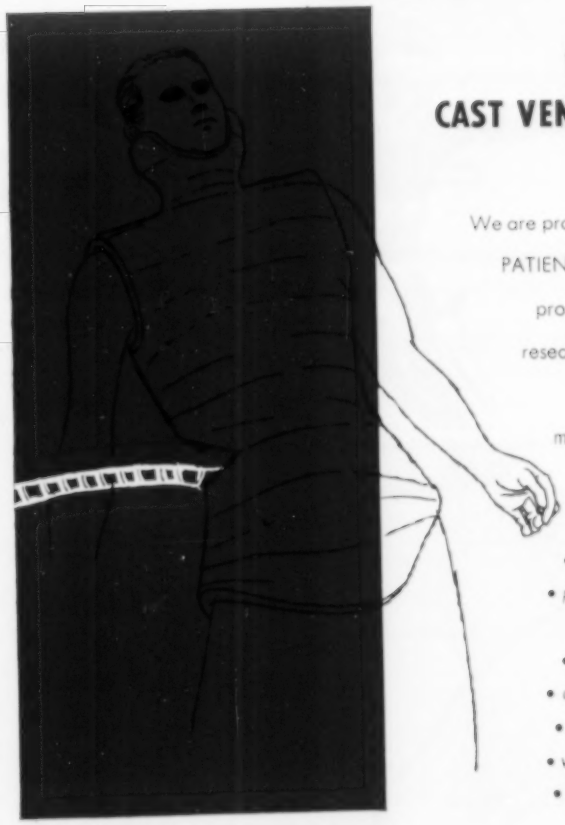


CHAS. A. SCHMIDT SURGICAL INSTRUMENT COMPANY

3689 Olive Street, Saint Louis 8, Missouri

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

PATIENT aire



for under
CAST VENTILATION

We are proud to introduce PATIENT-AIRE, another product of Conco's research into modern materials for modern medicine.

- *reduces itching*
- *prolongs cast life*
- *dries cast*
- *diminishes odor*
- *avoids ulceration*
- *cools under cast*
- *warms under cast*
- *X-ray permeable*

CONCO
SURGICAL PRODUCTS, INC.

RESEARCH • DEVELOPMENT • PRODUCTS
BRIDGEPORT • CONNECTICUT

wright series two

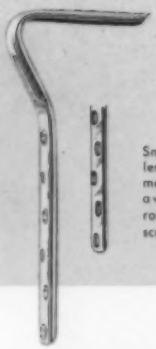
THE SEPARATE STRUCTURES OF THE HUMAN BODY AND THE COMPARATIVE INSTRUMENTS OF THE ORTHOPAEDIC SURGEON

the upper leg
(femur)

Smo Type 316 Stainless Steel Diamond Shaped, Vesely-Street Split Nails are designed to prevent rotation when used in fractures of the upper or lower third of the long bones of the leg.

WRITE TO DEPT. LU-2, WRIGHT MFG. CO., 880 ADAMS, MEMPHIS, TENN. FOR FURTHER INFORMATION.

Smo Type 316 Stainless Steel Jewett, completely drop-forged, one piece Cannulated, Supercondylar Nails are designed to fit snugly - the contours of the condyles and shaft of the femur. The plates are available with round or elongated screw holes.



Smo Type 316 Stainless Steel Lower Femoral Blade Plate is available with round or elongated screw holes.

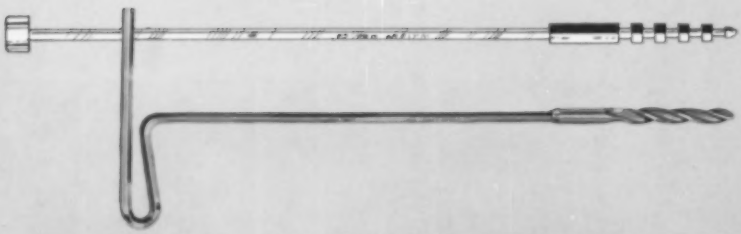
Stainless Steel Double Duty, Driver-Extractor for the Hansen- Street Nail with the Retrograde Adapter.

Smo Type 316 Stainless Steel Hansen-Street, Single threaded Intramedullary Nail. This elongated Diamond -shaped nail causes less rotation and thereby produces better and stronger fixation.

Smo Type 316 Stainless Steel Hansen-Street Intramedullary Nail with Broached Ends. This broached nail lessens the danger of splitting the bone shaft during insertion.

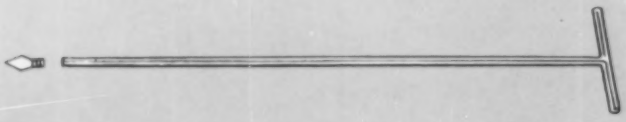
Smo Type 316 Stainless Steel Hansen-Street, Double Threaded Intramedullary Nail.

Smo Type 316 Stainless Steel Lottes Femur Nail - Triflange designed to prevent rotation.



Stainless Steel Broach for the Hansen-Street Nail.

Stainless Steel Reamer for the Hansen-Street Nail with the twist drill end for easy reaming.



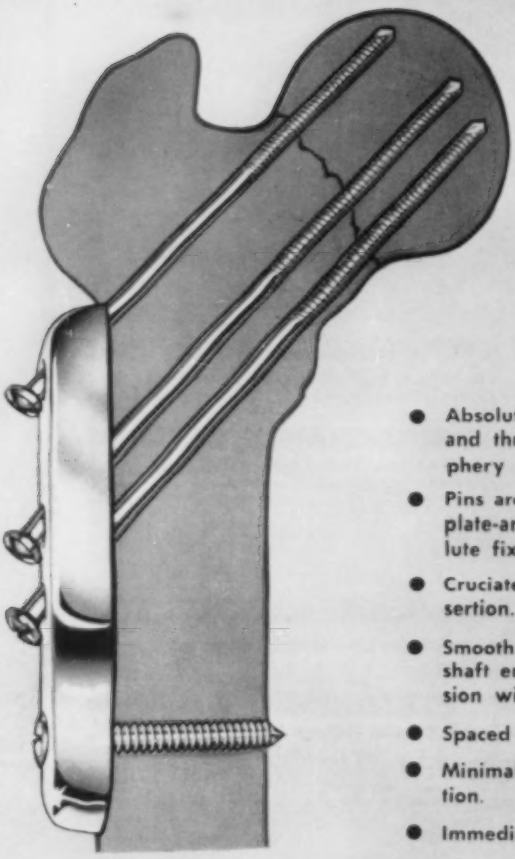
Stainless Steel Guide Wire for the Lottes Nail with convenient guide handle.

Wright Manufacturing Company

SMO

TYPE 316 STAINLESS STEEL IS INERT IN SUBSTANCE, EXISTING ON THE FRIENDLIEST OF TERMS WITH BONE, BODY FLUIDS AND SOFT TISSUES. ALL WRIGHT SMO TYPE 316 STAINLESS STEEL IMPLANTS ARE ELECTROPOLISHED AND PACKED IN POLYETHYLENE ENVELOPES TO ASSURE THE SURGEON OF COMPLETE METAL SURFACE CLEANLINESS.

880 Adams • Memphis, Tennessee



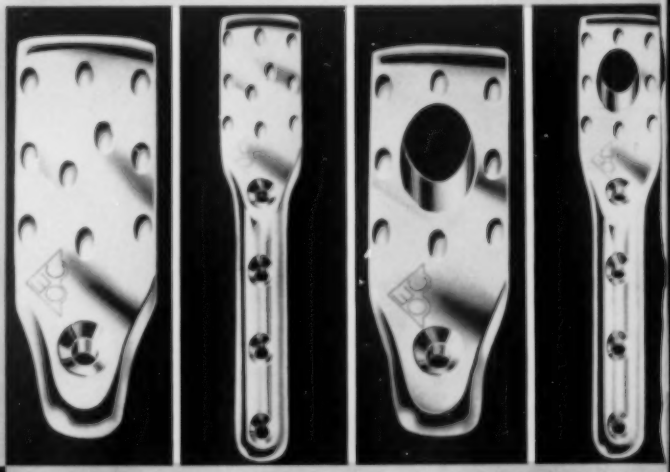
DEYERLE HIP FIXATION

IN SMo AISI-316

- Absolute fixation obtained with Deyerle plate and threaded pins inserted DEEP into the peri phery of the head cortex.
- Pins are held in pre-selected angle (140°) by the plate-and-guide combination allowing for absolute fixation of the shaft end.
- Cruciate (Woodruff) head pins for ease of insertion.
- Smooth shanks allow for sliding of the pins in shaft end portion and maintain contact compression without loss of reduction or position.
- Spaced radially to prevent rotation.
- Minimal pressure necrosis with peripheral fixation.
- Immediate weight bearing.

Technique published in Clinical Orthopaedics, No. 13, 1959 (J. B. Lippincott Co.). Dr. Wm. M. Deyerle, Dept. of Orthopaedic Surgery, Medical College of Virginia, Richmond, Va.

20 minute 16 mm color sound film available on request.



ORTHOPEDIC EQUIPMENT CO.
Bourbon, Indiana

EUROPEAN ASSOCIATES: ZIMMER ORTHOPAEDIC LTD., Bridgend, Glam, Great Britain

ORTOPEDIA G.m.b.H. KIEL, Kiel, Germany

AVAILABLE FROM YOUR SURGICAL SUPPLY DEALER

The Journal of
Bone and Joint Surgery

American Volume

Observations on Non-Union of the Shafts of the Long Bones, with a Statistical Analysis of 842 Patients*

BY HAROLD B. BOYD, M.D., S. W. LIPINSKI, M.D., AND JAMES H. WILEY, M.D.,
MEMPHIS, TENNESSEE

From the Campbell Foundation and the University of Tennessee College of Medicine, Memphis

A fractured bone usually heals by the formation of new bone at the fracture site. Occasionally, only fibrous tissue is formed; when this happens, both surgeon and patient are disappointed. Yet biologically, one may ask why fibrous union is not more common since most tissues heal by fibrous union. We do not expect muscle, kidney, or brain to heal by regeneration of the specific tissue. Why should we expect such a highly differentiated tissue as bone to regenerate? The fact that bone is a specialized form of connective tissue may account for its ability to heal by the formation of new bone. But the process by which apatite crystals are deposited in and on the collagen fibers of newly formed bone matrix and the process by which the bone callus so formed is remodeled into mature bone are poorly understood. We do not understand the motivating or induction factors involved; we recognize no more than the most obvious causes of non-union. We have no sound rational grounds for our therapeutic measures to correct non-union. Our treatment still rests primarily on an empirical basis. The scientist can always defer his decision until further data are collected and analyzed. By contrast, the surgeon must make a prompt decision based on available experience.

With these thoughts in mind, we are presenting an analysis of the experience of the staff of the Campbell Clinic in the management of 842 patients with non-union of the shafts of long bones treated prior to 1959.

ANALYSIS OF 842 PATIENTS

Chart I presents in histographic form the course of the 842 patients on whom 919 operations for non-union were performed and 1013 bone-grafting procedures were employed. The difference in these two numbers is accounted for by the fact that when a patient underwent an operation for non-union of both bones of the forearm, he may have had two different procedures performed in one operation

* Some of this material has been published in another form *In* Rapports Présentés au Huitième Congrès, New York, 4–9 Septembre, 1960. Fasc. 1, pp. 29–52, Société Internationale de Chirurgie Orthopédique et de Traumatologie, Bruxelles, [Spring] 1960.

since the method of bone-grafting used on the radius was not necessarily the same as that used on the ulna. Also, in evaluating results, either the radius or the ulna may have united and the other failed. If this happened, the patient was listed at that time as a failure. All patients lost to follow-up were assumed to be failures. The incidence of failure in all the bone-grafting procedures was 13.5 per cent, whereas the ultimate incidence of failure for the 842 patients (some had several operations) was 6 per cent. In all, 790 patients (94 per cent) eventually obtained union.

Chart II shows that 674 patients (80 per cent) were referred to us with existing non-unions; non-union developed in the remaining 168 (20 per cent) after treatment of their acute fractures by us. Of the referred patients, 108 had had from one to six operations for non-union prior to referral.

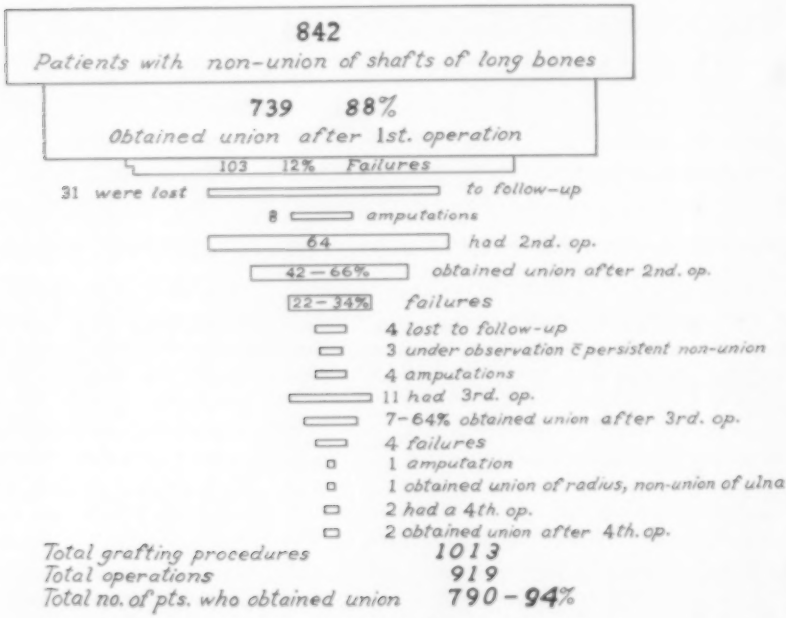


CHART I

Histogram of the course of 842 patients with non-union of the shafts of long bones.

PREDISPOSING CAUSES OF NON-UNION

Chart III shows for each bone in this series the incidence of open fractures, the incidence of open reduction and internal fixation of both the closed and open fractures, and the incidence of infection following the acute fracture. (These percentages, of course, overlap.) Open fractures were most common in the tibia and next most common in both bones of the forearm. Infection was most frequent in the tibia, and least frequent in the femur (except the clavicle, where it did not occur at all). Open reduction and internal fixation was used most frequently in fractures of the radius alone and in fractures of both bones of the forearm, indicating the difficulty of securing satisfactory reduction of these fractures in adults. All of these conditions predisposed to non-union.

Interruption of the blood supply, particularly in the middle segments of double fractures, also predisposed to non-union, as did the presence of multiple fractures. These multiple injuries were the result of severe trauma which, no

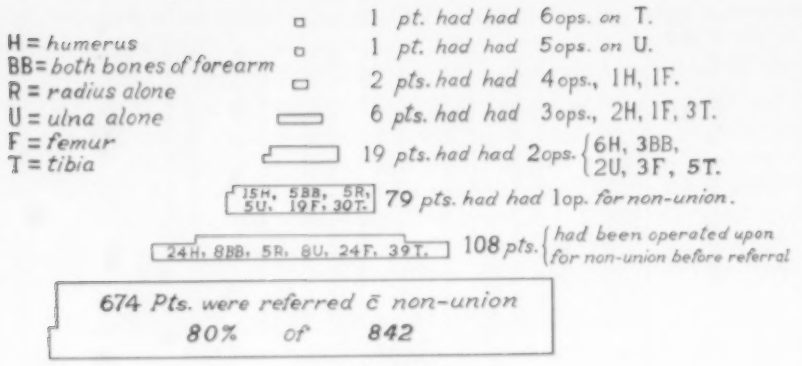

H = humerus
BB = both bones of forearm
R = radius alone
U = ulna alone
F = femur
T = tibia
1 pt. had had 6 ops. on T.
1 pt. had had 5 ops. on U.
2 pts. had had 4 ops., 1H, 1F.
6 pts. had had 3 ops., 2H, 1F, 3T.
19 pts. had had 2 ops. {6H, 3BB, 2U, 3F, 5T.
15H, 5BB, 5R, 5U, 19F, 30T. 79 pts. had had 1 op. for non-union.
24H, 8BB, 5R, 8U, 24F, 39T. 108 pts. {had been operated upon for non-union before referral
674 Pts. were referred ē non-union
80% of 842

CHART II

Histogram of 674 patients referred with existing non-union, and their operative course before referral.

doubt, contributed to the non-union. However, patients with multiple fractures inevitably run a greater risk of non-union since, for example, a patient with three fractures has three times as many opportunities for non-union to develop as does a patient with one fracture.

Lack of contact between the bone ends also predisposed to both delayed union and non-union. The lack of contact was the result of poor reduction, failure of fixation, or distraction. For example, it was frequently observed that the bone ends were held apart by the plate and screws used for internal fixation or were distracted by skeletal traction.

Urist and associates estimated that union of a fracture is delayed as much as twelve to eighteen months by a gap of more than half a centimeter between the bone ends.

Inadequate internal fixation after open reduction—for example, a plate that was too small or a plate that had only one screw in one of the fragments—was often a predisposing cause of non-union.

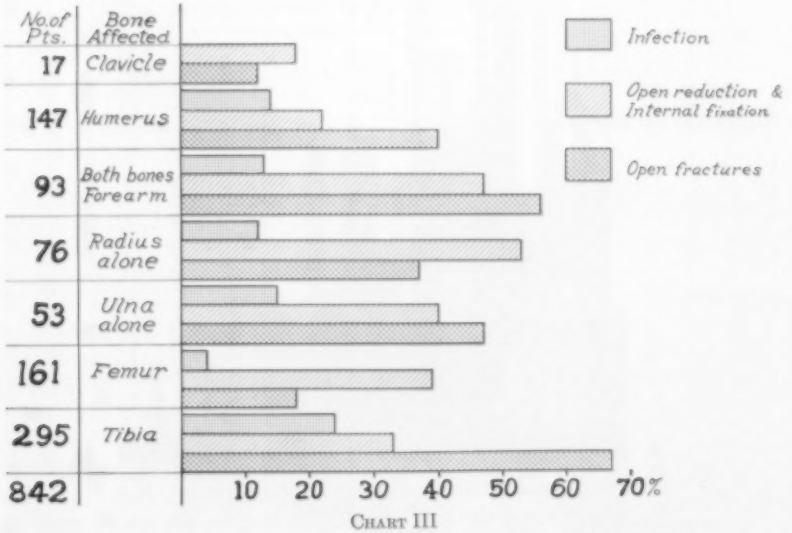


CHART III

Graph of major predisposing causes of non-union in individual bones.

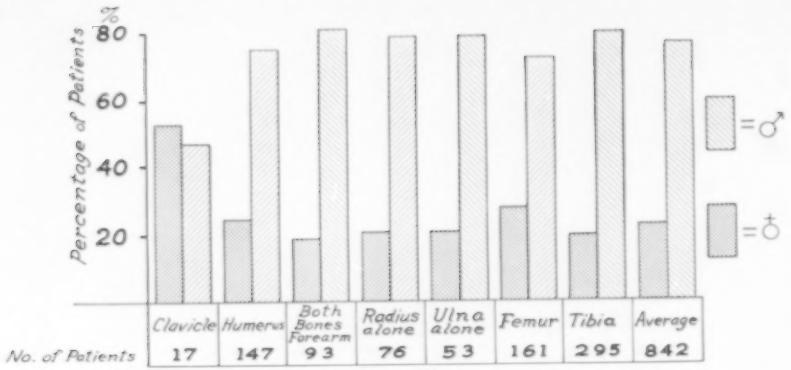


CHART IV

Graph of the relative percentage, by bone, of male and female patients in the series.

Influence of Sex and Age

Chart IV shows the relative incidence, by bone, of the ununited fractures in the male and female patients in the series. The significance of these data is not known. They could be interpreted to mean that fractures unite more readily in women than they do in men, but the more likely interpretation is that men sustain more fractures and their fractures are of a type more prone to non-union.

Chart V shows the distribution of patients by age. Non-union in children was rare in this series. The youngest patient was ten years old; only fifteen patients were below the age of sixteen. In these children, however, vigorous therapy was indicated; such non-unions should be regarded as comparable with congenital pseudarthroses [2,3].

The largest number of non-unions occurred in patients between the ages of

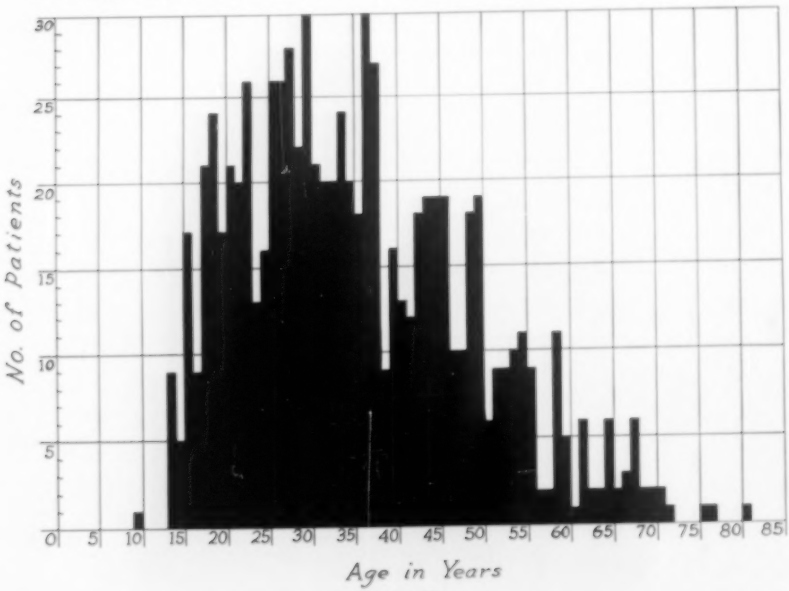


CHART V

Graph of distribution of the patients by age.

twenty-two and thirty-eight: these are the more active years, when severe or extensive trauma is apt to occur.

The number of surgical procedures for the correction of non-union in this series diminished in the patient over fifty, but the prognosis for successful repair of non-union in these older patients appeared to be only slightly modified by their age. For the thirty-five patients who were over sixty years old, the rate of union after the first operation for non-union was 83 per cent, as compared with 88 per cent for the 807 patients sixty years old or younger. It is also of interest that of the last 100 patients operated on for non-union, 11 per cent were over sixty years old, whereas in the previous 742 patients, only 3 per cent were over sixty.

OBSERVATIONS ON TREATMENT

Chart VI shows the rate of success and failure for the various methods of bone-grafting employed. Numerically, these data are weighted in favor of the onlay graft (63 per cent), a method especially popular here for years after it was

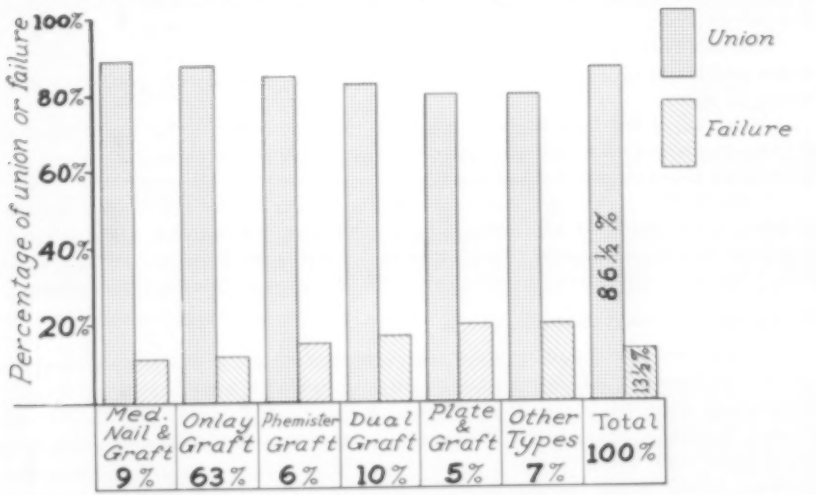


CHART VI

Graph of the percentage of success or failure of the various methods of bone-grafting employed.

described by Henderson and by Campbell. More recently, other methods have become popular, but sufficient time has not elapsed for them to constitute a large percentage of the series. As yet, there are not sufficient numbers of cases treated by these other methods to permit statistically valid comparisons.

This chart suggests, however, that success or failure in the treatment of non-union is not influenced by the technique employed, as much as might be anticipated. Of course, this statement is valid only if due allowance is made for the selection of a method appropriate to a specific non-union. Obviously, the indications for a Phemister graft are quite different from those for a dual onlay graft. With due allowances for such indications it is of some interest to consider the possibility that provided the method selected is in accordance with good surgical judgment, it makes little difference what procedure is employed. When a fracture occurs, the body usually responds to this insult by the formation of new bone, and healing of the fracture ensues. If this response is not forthcoming,

non-union results. In essence, a bone-grafting procedure is a new insult produced by the surgeon in the hope that the response to this second insult will be more favorable. Perhaps the efficacy of this second insult to produce healing is not so dependent on the specific type of grafting procedure as the surgeon would like to believe, especially when he has performed his favorite operation.

The average time interval between successful bone-grafting and union sound enough to allow function without support varied from six months for the humerus to eight and one-half months for the tibia.

Factors Promoting Union

The indispensable factor for union is osteogenesis, but other factors which appear to promote union are contact of the bone ends, solid fixation of the fragments, and compression at the fracture site.

Osteogenesis is essential. To our knowledge, no medication is available to shorten the time required for bone to heal. However, in this series, as will be apparent, autogenous cancellous bone packed about the site of non-union was the best substance to stimulate osteogenesis and thus to promote union.

Contact between the bone ends is essential to prompt healing. Any gap requires additional time for the formation of callus to bridge it; any gap may cause failure of union.

Fixation, either by external means (such as a cast) or by rigid internal devices, continued for a sufficient period of time for union to occur, was necessary for healing of non-union to take place.

Compression, although not essential, is desirable [6,9,13]. It is not known whether compression of the cortical bone promotes osteogenesis or whether it promotes earlier union simply by diminution of the space between the fragments to be filled by callus and more efficient immobilization of the fracture surface.

Homogenous versus Autogenous Grafts

In this series, both homogenous and autogenous-bone grafts were used alone and in combination. The homogenous grafts were frozen bone from our bank or freeze-dried bone from the Tissue Bank of the United States Naval Medical Center, Bethesda, Maryland [12]. There were sixty-two procedures in which homografts alone were used. Of these, forty-three (70 per cent) resulted in union and nineteen failed. In the remaining 951 procedures, autogenous grafts alone were used in 766 and a combination of autogenous and homogenous grafts was used in 185. Union resulted in 834 (88 per cent); 117 were failures. Eight of the combined autogenous and homogenous-bone-grafting procedures were dual grafts, with one graft autogenous and one homogenous. Thus, with autogenous grafts the incidence of union was 18 per cent higher than when only homogenous grafts were used. Of course, factors other than the kind of bone graft used had some influence on this figure, but we agree with Hyatt and Butler and with Peer that autogenous grafts are to be preferred unless there are specific indications to the contrary.

The antigen-antibody response to grafts of homogenous tissue, well demonstrated experimentally for skin by Medawar and by Peer, has not, to our knowledge, been demonstrated for bone. Clinically, homogenous-bone grafts may be rejected rapidly or they may be replaced gradually by host bone. Perhaps bone grafts fare as well as they do because bone is not a highly cellular tissue, and its individual cells are protected by the calcified intercellular matrix with the result that the amount of antigen reaching the host at any one time is small. If so, this is a fortunate fact, for on occasion homogenous bone is a valuable substitute for

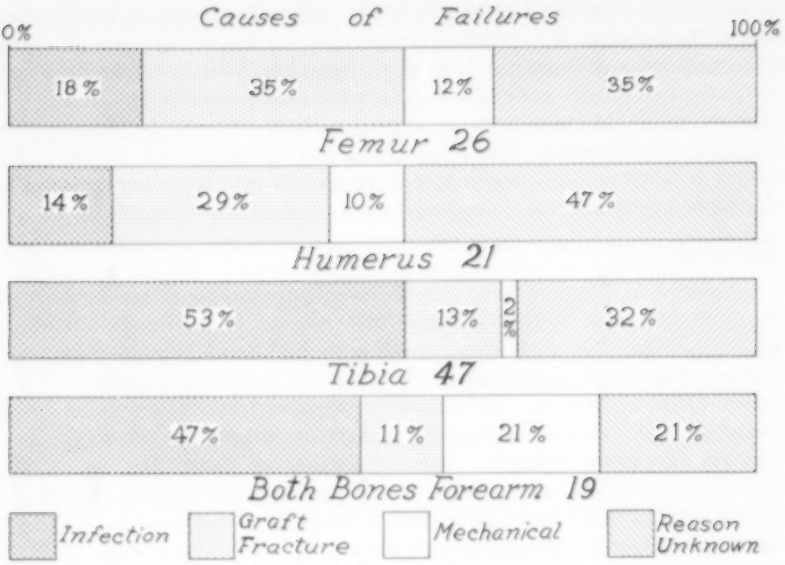


CHART VII

Analysis of causes of failure in four regions: two proximal (femur and humerus), and two distal (tibia and both bones of forearm). In the distal regions, infection predominated; in the proximal, fracture of the graft.

autogenous bone. But it should not be forgotten that the host accepts and utilizes autogenous tissue more rapidly and with less difficulty than homogenous tissue, and that whenever homogenous bone is used, there should be good reason for choosing second-best material.

ANALYSIS OF FAILURES

The number of failures after the first through the fourth operations are shown in Chart I, and the percentage of failures for the various methods of grafting are shown in Chart VI. As we have said, 13.5 per cent of all grafting procedures failed, and 6 per cent of all patients (including those lost to follow-up) failed to obtain union.

Chart VII presents an analysis of the causes of failure in four regions: the distal limb segments (the tibia and both bones of the forearm) and the proximal segments (femur and humerus).

In the tibia and both bones of the forearm postoperative infection was the principal cause of failure. Usually the infection was a recrudescence of an old infection that had occurred in an open fracture or after open reduction of a closed fracture. In the humerus and femur, on the other hand, the principal cause of failure was fracture of the graft or inadequate fixation.

The numerical incidence of these two principal causes of failure (infection and fracture of the graft) in the femur and humerus was the reverse of that in the tibia and both bones of the forearm. Adequate fixation is more difficult to obtain in the proximal limb segments (femur and humerus), and this difficulty accounts for more fractures of the graft in those bones. Conversely, infection is more likely in the distal limb segments (tibia and forearm), where open fractures are more frequent and the bones less well protected by large muscle masses.

An exception to this rule was noted in the seventy-six non-unions of the radius alone. There were twelve failures here, with fracture of the graft in seven (58

per cent). This suggests the importance of controlling bending and torsional forces in the forearm.

In non-union of the ulna alone, there were only three failures among fifty-three patients; all three non-unions united after a second operation.

However, in the ninety-three non-unions of both bones of the forearm, there were eight cases in which the radius united and the ulna failed to unite. This situation in some instances was due to angulation of the radius, narrowing of the interosseous space, and consequent distraction of the ulnar fragments.

Amputations

As shown in Chart I there were thirteen amputations in the series; these were all in the lower extremity (three for non-union in the femur and ten for non-union in the tibia). All amputations were performed because of recurrent infection. Amputation is indicated when the function of a prosthesis will be superior to that which can be reasonably expected from the surgically reconstructed limb. One should also consider that the patient with an infected, draining non-union of a lower extremity faces long periods of immobilization, stiffened joints, possible amyloid disease, and a major surgical procedure which may shorten the limb, and he still has no guarantee of union. If amputation is elected, the patient's morale, often exhausted by prolonged disability, may be restored by the rapid rehabilitation which can follow the fitting of a prosthesis.

CHOICE OF PROCEDURE

The type of graft best suited to an individual non-union varies with circumstances, and is a matter of surgical judgment and the individual preference of the surgeon. But some general principles derived from this study may be useful as guides. For non-union of the middle third of the femur, humerus [16], and ulna, medullary fixation with the addition of autogenous cancellous bone about the site of non-union is usually best. The nail must be large enough to prevent rotation; if it is not, screws should be inserted as set screws to fix the nail firmly or an auxiliary onlay graft may be necessary to control rotation. This is especially true in the femur. Prebent medullary nails may be used in the radius (for example, the Sage nail [20]) or in the tibia (for example, the Lottes nail [14]). Anatomically, however, these bones are not conveniently shaped for medullary fixation.

The onlay cortical graft, or metal plate, with additional autogenous cancellous bone, has proved to be of value in treating non-union of the tibia and of the lower third of the femur, humerus, radius, and ulna. A metal plate should be used in preference to a cortical graft when additional strength is required, especially if bending forces are strong. If a metal plate is chosen, more autogenous cancellous bone should be packed about the site of non-union, for metal has no osteogenic properties. Of all methods of internal fixation the autogenous cortical graft is best tolerated and assists in stimulating union [1].

The Phemister graft has been useful in non-union of the tibia when the bone fragments were in acceptable position and no correction of angulation or offset was necessary. In thirty-one patients who had tibial non-union of this type, the Phemister graft was successful in twenty-nine (94 per cent) and failed in only two (6 per cent). In contrast to this the over-all failure rate with this type of graft was 18 per cent. These data suggest that the Phemister graft is not usually suitable for use in the humerus, femur, and radius where bending and rotary forces are strong, and rigid fixation is required to maintain close coaptation of the graft with the host bone. To avoid disturbing the original wound we also used the Phemister graft in tibial non-union where there was quiescent infection [8].

Sometimes a large defect must be bridged. In the tibia, we used the Flanagan and Burem half-cylinder sliding graft on two occasions; in the humerus and forearm bones, fibular grafts [3]. Nicoll described the use of cancellous bone to fill such gaps, but we have not employed this method.

The dual onlay graft [2] is useful in treating non-union near joints, where the fragment adjacent to the joint is short and, often, osteoporotic; the viselike action of the dual graft can hold this fragment securely.

If good judgment is exercised in the selection of the method of treatment for the different kinds of non-unions described, the prognosis, as this study suggests, is surprisingly similar whatever method is used.

SUMMARY

1. Since the treatment of non-union is still of necessity empirical, we have reviewed our experience with 842 patients who had non-union of fractures in the shafts of long bones.

2. The factors predisposing to non-union include those incident to injury and to treatment. The principal predisposing factors related to the injury are exposure of the fracture site at the time of injury (open fractures), comminution, disturbance of the blood supply, infection, or any combination of these. The principal factors incident to treatment are ill-advised open reduction, infection, distraction of the bone ends, and immobilization that is either insecure, incomplete, or too briefly maintained.

3. The chief factors promoting union are osteogenesis, contact, fixation, and compression. In grafting, autogenous bone is preferable to homogenous bone.

4. Types of bone-grafting procedures best suited for individual bones and for specific locations are discussed.

5. Of the 842 patients, 790 (94 per cent) eventually obtained union, but 64 required more than one operation to do so. An analysis of the operative failures and the indications for amputation are presented.

REFERENCES

1. Abbott, L. C.; Schottstaedt, E. R.; Saunders, J. B. DeC. M.; and Bost, F. C.: The Evaluation of Cortical and Cancellous Bone as Grafting Material. A Clinical and Experimental Study. J. Bone and Joint Surg., **29**: 381–414, Apr. 1947.
2. Boyd, H. B.: Congenital Pseudarthrosis. Treatment by Dual Bone Grafts. J. Bone and Joint Surg., **23**: 497–515, July 1941.
3. Boyd, H. B.: The Treatment of Difficult and Unusual Non-Unions. With Special Reference to the Bridging of Defects. J. Bone and Joint Surg., **25**: 535–552, July 1943.
4. Boyd, H. B., and Sage, F. P.: Congenital Pseudarthrosis of the Tibia. J. Bone and Joint Surg., **40-A**: 1245–1270, Dec. 1958.
5. Campbell, W. C.: The Treatment of Ununited Fractures. Am. J. Surg., **37**: 1–3, 1923.
6. Charnley, John: Compression Arthrodesis, Including Central Dislocation As a Principle in Hip Surgery. Edinburgh, E. and S. Livingstone, 1953.
7. Chase, S. W., and Herndon, C. H.: The Fate of Autogenous and Homogenous Bone Grafts. A Historical Review. J. Bone and Joint Surg., **37-A**: 809–841, July 1955.
8. Cleveland, Mather, and Winant, E. M.: Treatment of Non-Union in Compound Fractures with Infection. J. Bone and Joint Surg., **34-A**: 554–563, July 1952.
9. Eggers, G. W. N.; Shindler, T. O.; and Pomerat, C. M.: The Influence of the Contact-Compression Factor on Osteogenesis in Surgical Fractures. J. Bone and Joint Surg., **31-A**: 693–716, Oct. 1949.
10. Flanagan, J. J., and Burem, H. S.: Reconstruction of Defects of the Tibia and Femur with Apposing Massive Grafts from the Affected Bone. J. Bone and Joint Surg., **29**: 587–597, July 1947.
11. Henderson, M. S.: Nonunion in Fractures. The Massive Bone Graft. J. Am. Med. Assn., **81**: 463–468, 1923.
12. Hyatt, G. W., and Butler, M. C.: Bone Grafting. The Procurement, Storage, and Clinical Use of Bone Homografts. *In* Instructional Course Lectures, The American Academy of Orthopaedic Surgeons, 1957. Vol. 14, pp. 343–373. Ann Arbor, J. W. Edwards, 1957.
13. King, Thomas: Compression of the Bone Ends as an Aid to Union in Fractures. A Report on Forty-nine Ununited and Four Recent Fractures. J. Bone and Joint Surg., **39-A**: 1238–1248, Dec. 1957.
14. Lottes, J. O.; Hill, L. J.; and Key, J. A.: Closed Reduction, Plate Fixation, and Medullary

Nailing of Fractures of Both Bones of the Leg. A Comparative End-Result Study. J. Bone and Joint Surg., **34-A:** 861–877, Oct. 1952.

15. Medawar, P. B.: Behaviour and Fate of Skin Autografts and Skin Homografts in Rabbits (Reports to War Wounds Committee of Medical Research Council). J. Anat., **78:** 176–199, 1944.
16. Merle d'Aubigné, Robert: Surgical Treatment of Non-Union of Long Bones. J. Bone and Joint Surg., **31-A:** 256–266, Apr. 1949.
17. Nicoll, E. A.: The Treatment of Gaps in Long Bones by Cancellous Insert Grafts. J. Bone and Joint Surg., **38-B:** 70-82, Feb. 1956.
18. Peer, L. A.: Transplantation of Tissues. Baltimore, The Williams and Wilkins Co. Vol. 1: Cartilage, Bone, Fascia, Tendon and Muscle, 1955. Vol. 2: Skin, Cornea, Fat, Nerves, Teeth, Blood Vessels, Endocrine Glands, Organs, Peritoneum, Cancer Cells, 1959.
19. Phemister, D. B.: Treatment of Ununited Fractures by Onlay Bone Grafts without Screw or Tie Fixation and without Breaking down of the Fibrous Union. J. Bone and Joint Surg., **29:** 946–960, Oct. 1947.
20. Sage, F. P.: Medullary Fixation of Forearm Fractures. A Study of the Medullary Canal of the Radius and a Report of Fifty Fractures of the Radius Treated with a Prebent Triangular Nail. J. Bone and Joint Surg., **41-A:** 1489-1516, Dec. 1959.
21. Urist, M. R.; Mazet, Robert, Jr.; and McLean, F. C.: The Pathogenesis and Treatment of Delayed Union and Non-Union. A Survey of Eighty-five Ununited Fractures of the Shaft of the Tibia and One Hundred Control Cases with Similar Injuries. J. Bone and Joint Surg., **36-A:** 931–968, Oct. 1954.

The Fabellofibular and Short Lateral Ligaments of the Knee Joint

BY EMANUEL B. KAPLAN, M.D., NEW YORK, N. Y.

From the Department of Anatomy, College of Physicians and Surgeons, Columbia University, and the Hospital for Joint Diseases, New York

The ligamentous structures of the posterior, medial, and lateral regions of the knee joint are functionally and morphologically connected with the corresponding muscles. Continued studies of functional relationships are necessary for better understanding of the knee. Investigations of function are much clarified by the use of comparative anatomical methods.

The following ligaments are generally described in connection with the posterior capsule: the medial collateral ligament, the oblique popliteal ligament of Winslow, the arcuate ligament with its relationship to the popliteus tendon and muscle, the lateral collateral ligament, and the short lateral ligament (Fig. 1).

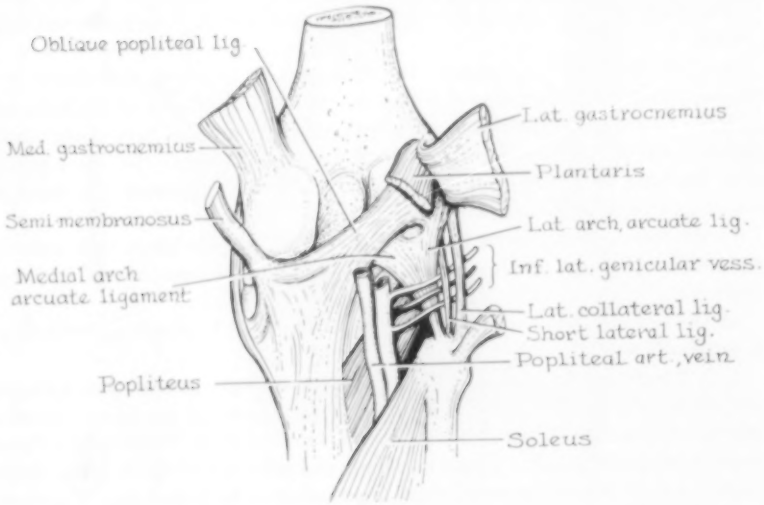


FIG. 1

Diagrammatic illustration of the posterior aspect of the right knee joint. The inferior lateral genicular vessels are seen running over the lateral arch of the arcuate ligament and under the short lateral and lateral collateral ligaments. No fabella is present.

OBJECT AND PURPOSE

This investigation concerns a ligament that differs from the short lateral ligament and is occasionally found posterior to the lateral collateral ligament and parallel to it. In most textbooks the short lateral ligament is either described briefly in connection with the lateral collateral ligament [6,10,20] or is completely omitted [1,2,21,24,25,27].

The ligament, which I have termed the *fabellofibular ligament*, differs from the short lateral ligament in size and relationship to the lateral collateral ligament; it may cause confusion during surgical exposure of this part of the knee.

The purpose of this study is to establish the correct relationship of this liga-

ment to the other structures of the posterolateral aspect of the knee, its incidence, and its morphological and functional significance, as well as its relative importance in surgical anatomy of the joint.

To differentiate the fabellofibular ligament clearly from the short lateral ligament, it is necessary to give the description of the short lateral ligament as found in the literature. The best recent description, in English, of the short lateral ligament is given by Last [18], who stated that it might be described as the deep part of the lateral ligament of the knee joint that is attached above to the lateral condyle of the femur and below to the styloid process and medial (tibial) border of the upper surface of the head of the fibula. Its free posterior border, lying over the popliteus fascia and firmly adherent to it, constitutes the arcuate ligament; the tendon of the popliteus muscle ". . . is firmly attached along its lateral surface to the joint capsule, which, here, is very strong and consists of the lateral limb of the arcuate ligament. . . . Fused to the popliteus tendon at its femoral attachment is the upper end of the powerful 'short external lateral ligament' (of Old Terminology, non-existent in modern nomenclature). . . . It is blended with the capsule of the joint in front of the popliteus tendon and, morphologically, has been deemed to be a thickened part of the capsule. It serves functionally to reinforce the lateral ligament of the knee joint with which indeed it is equal in strength. . . . Sometimes, however, it is absent."

The Paris *Nomina Anatomica* of 1955 does not list the short external lateral ligament.

In 1905, the French anatomist, Dujarier, gave an excellent description of the short lateral ligament; he called it the peroneosesamoid ligament of the knee joint. According to Dujarier, the most anterior fibers of the fibular part of the arcuate ligament form a fairly resistant ligament, which was named the short external lateral ligament, or ligament of Bertin. Proximally, this ligament is inserted into the sesamoid bone of the lateral gastrocnemius.

In the recent French book on anatomy by Paturet, the ligament is called the sesamofibular ligament of Dujarier, or the posterolateral ligament of Meckel and Macalister, or the short external lateral ligament of Vallois.

In the German literature the short lateral ligament is known as the retinaculum ligamenti arcuati [9,16,26,28].

It is interesting to note that the same short lateral ligament was accurately described in 1742 by the German anatomist, Weitbrecht, of the Saint Petersburg Academy of Sciences. A translation of the Latin text from Weitbrecht's *Syndesmologia* is purposely cited: "There is behind and adjacent to the lateral collateral ligament, a short lateral ligament which is attached to the lowest part of the lateral femoral condyle, or its little bone, and extends beyond the dorsum of the semilunar cartilage to end at the apex of the fibula. In its passage, it reinforces the posterior capsule. Probably the ligament does not bind the femur as much as it appears to connect the semilunar cartilage to the inferior retinaculum: Frequently, the ligament does not appear to end on the femur, but in the upper region of the capsule above the semilunar cartilage" (Fig. 2).

There is a similarity in the descriptions of Paturet, Last, and others, although Last places the upper insertion of the ligament near the femoral insertion of the popliteus tendon, whereas Paturet and the others describe the proximal end at the lateral sesamoid (fabella) of the gastrocnemius.

Thus, we find the short lateral ligament described mostly as a part of the lateral arch of the arcuate ligament, or as a reinforcement of the posterior capsule.

The short lateral ligament has been variously named by the different authors, already mentioned, as: the short external lateral ligament [17,18,19]; the short external

lateral ligament of Bertin [2]; the short external lateral ligament [29,30]; the short lateral ligament [32]; the retinaculum ligamenti arcuati (German anatomical literature); the posterolateral ligament (Meckel and Macalister, cited by Paturet); the peroneosesamoid ligament [3]; and the sesamofibular ligament of Dujarier [23]. Although most of the observers referred to this short ligament as the short external lateral ligament, an attempt by others was also made to give it a more descriptive name.

In order to establish the reason for variations in the strength, length, presence, and absence of the fabellofibular ligament and the morphological relationship of the ligament to the fabella and fibula, a systematic study of the human knee combined with comparative anatomical studies was made.

FIG. 2

Photographic reproduction of the illustration of the posterior aspect of the right knee joint from Weitbrecht's *Syndesomologia, sive Historia Ligamentorum Corporis Humani quam Secundum Observationes Anatomicas Concinnavit*, Tabula XX, Fig. 59. *a* = os femoris; *b* = condylus ossis femoris externus; *c* = condylus internus; *d* = os tibiae; *e* = fibula; *f* = ligamentum laterale externum longum; *g* = ligamentum laterale brevius; *h* = ligamentum posticum Winslowii; *i* = tendo musculi semimembranosi; and *k* = expansiones membranaceae irregulares.

METHOD AND MATERIAL

One hundred and fifteen knees of seventy men and women were dissected. Some of the observations were made on material dissected by medical students in the course of their academic dissections in the laboratory. Additional observations were made on stillborn, premature, and full-term infants. This included twenty additional knees of ten infants. Comparative anatomical studies, limited in numbers, were made on representative specimens of reptiles, amphibians, a bird, an ornithorhynchus, marsupials, hoofed animals, carnivores, and anthropoids.

Important information was obtained from the literature on comparative anatomy [5,8,29,30,31].

RESULTS

Human Knees

The dissections of the human knees illustrated the structures described by most of the authors as parts of the posterior capsule of the knee. The oblique popliteal ligament was invariably present, as a more-or-less wide band running diagonally across from the tibial insertion of the tendon of the semimembranosus toward the origin of the lateral gastrocnemius over the lateral femoral condyle. The lateral border of the oblique popliteal ligament arched over the popliteus muscle, constituting the medial arch of the arcuate ligament. The lateral arch of the arcuate ligament was not always distinct. Some fibers representing the lateral arch of the arcuate ligament were running from the middle of the oblique popliteal

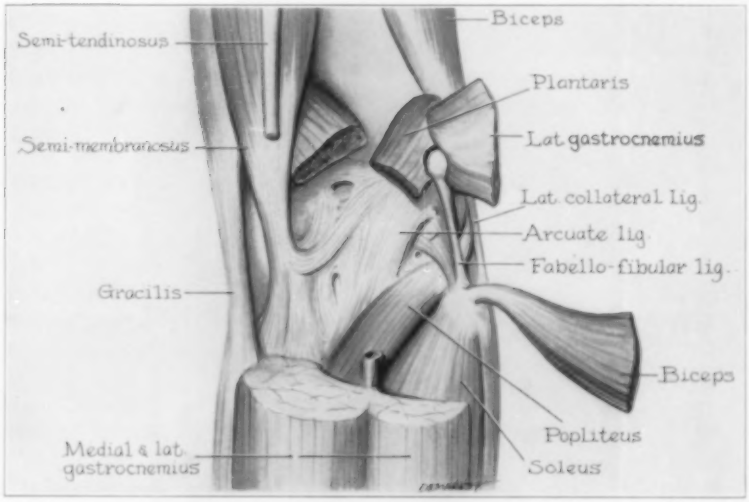


FIG. 3

Illustration of the fabellofibular ligament of the right knee joint. The relationship of the fabella, situated between the gastrocnemius and plantaris, to the ligament is shown. The relationship of the popliteus tendon to the lateral collateral ligament and to the fabellofibular ligament is to be noted.

ligament toward the head of the fibula, frequently blending with the posterior capsule of the joint to such an extent that, at times, it could not be easily dissected from the capsule or from the fascia covering the popliteus muscle. The inferior lateral genicular vessels coming from the popliteal vessels crossed the capsule and the lateral arch of the arcuate ligament and proceeded toward the lateral collateral ligament, coursing along the superficial surface of the capsule and passing deep to the lateral collateral ligament. The lateral and medial arch of the arcuate ligament join to form the arcuate ligament overlying the popliteus muscle, which is invested by its own popliteal fascia. Occasionally, instead of the lateral arch of the arcuate ligament, another structure originated near the condylar origin of the lateral gastrocnemius and ran toward the fibular head, forming a more distinct ligament than the lateral arch of the arcuate ligament. In the presence of this more defined ligament, the inferior lateral genicular vessels assumed a slightly different course, running between the capsule of the knee and this ligamentous structure, similar

to the course of the vessels between the capsule and the lateral collateral ligament. It is apparently this other ligament, which runs from under the gastrocnemius to the fibular head, that actually represents the short lateral ligament (Fig. 1). The medial border of this ligament blends with the lateral arch of the arcuate ligament. When this short lateral ligament is absent, the lateral arch of the arcuate ligament is considered by some authors to be the short lateral ligament.

An interesting observation was made in the course of dissection of the human knees. The absence of a lateral gastrocnemian fabella was always associated with either a complete absence or attenuation of the short lateral ligament. On the other hand, the presence of the lateral fabella, found bilaterally in five cadavera, was always associated with a notable change in the structure of the short lateral ligament. When the lateral fabella was present, the short lateral ligament was represented by a strong ligament, originating directly from the fabella and passing

FIG. 4-A

FIG. 4-B

Figs. 4-A and 4-B: Photographs of a specimen of the lateral aspect of a human right knee joint.
Fig. 4-A: The line of division of the biceps femoris is shown. The lateral gastrocnemius is partially excised; the patella is to the right. *a* = lateral collateral ligament; *b* = fabellofibular ligament; *c* = popliteus tendon; *d* = biceps divided; *e* = part of the lateral femoral condyle (*e* is not visible in this photograph because it is covered by the biceps muscle); *f* = lateral meniscus; (*g* = lateral gastrocnemian fabella, which is not visible in this photograph because it is partially covered by the biceps); and *h* = divided lateral gastrocnemius. On surgical exposure of this region, the fabellofibular ligament, when present, may be easily mistaken for the lateral collateral ligament.
Fig. 4-B: In the same specimen with the divided biceps muscle retracted proximally and distally from line of division, *a* = the fibular insertion of the lateral collateral ligament; *b* = the fabellofibular ligament; *d* = the biceps femoris; and *e* = part of the lateral femoral condyle.

between the condylar portions of the plantaris and lateral gastrocnemius muscles to the apex of the fibula. This ligament, almost equal in size to the lateral collateral ligament, ran almost parallel to the lateral collateral ligament toward the fibular head, where it inserted posterior to the insertion of the tendon of the biceps muscle, between the biceps tendon placed anteriorly and the lateral gastrocnemius muscle running posteriorly (Fig. 3). The distance between the fabellar origin of this ligament and the origin of the lateral collateral ligament on the femur was about two

centimeters, whereas the distance between the insertions of these two ligaments on the fibular head did not exceed 1.5 centimeters (Figs. 4-A and 4-B).

The inferior lateral genicular vessels were found to run between the capsule and the ligament in the same way that these vessels pass between the capsule and lateral collateral ligament, indicating the independence of the ligament from the capsule.

Because of this ligament's comparative independence, its connection with the fabella and fibula, and its difference in size as compared with the short lateral ligament, the name *fabellofibular ligament* seems justified. Further justification for this term will be found in the results of the study of the comparative anatomy of this structure and in the necessity for the recognition of this ligament during surgical exposures of this region.

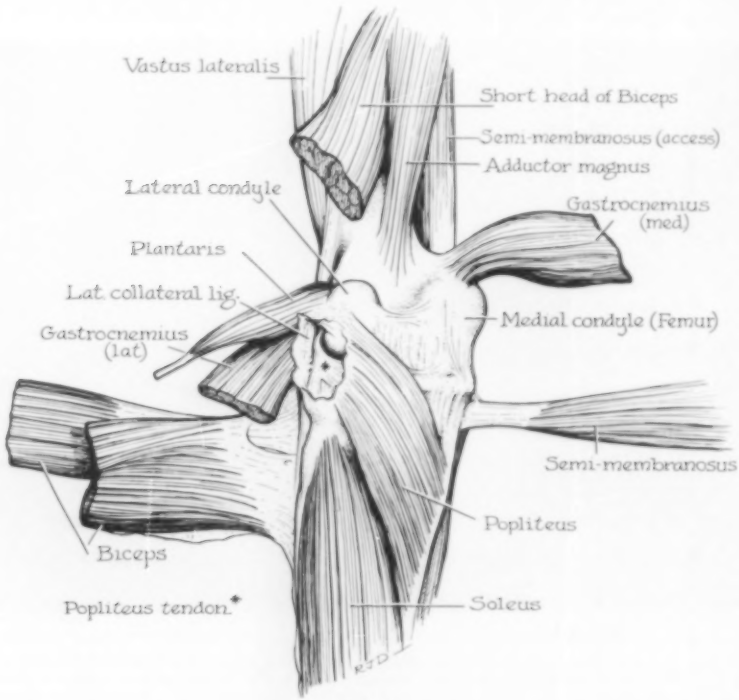


FIG. 5

Left knee joint of a chimpanzee. Note the relationship of the popliteus tendon to the fibular head and the tendinous extension of this tendon to the fibular head, also the extent of the popliteus muscle.

The presence of this ligament whenever a fabella is found and its attenuation, and even absence, when the fabella is absent suggest the conclusion that its incidence corresponds to the incidence of the lateral fabella. Roentgenographically and anatomically, the fabella is found in about 8 to 10 per cent of knees, but, according to some authorities, the incidence is as high as 16 per cent [7,15]. On the basis of this, it may be expected that the fabellofibular ligament may be present in from 8 to 16 per cent of knees. However, it must be taken into consideration that the ossification of the fabella occurs, according to available information, between a person's sixteenth and twentieth year [4]. One can therefore make a preliminary roentgenographic diagnosis of the presence of the fabellofibular ligament prior to

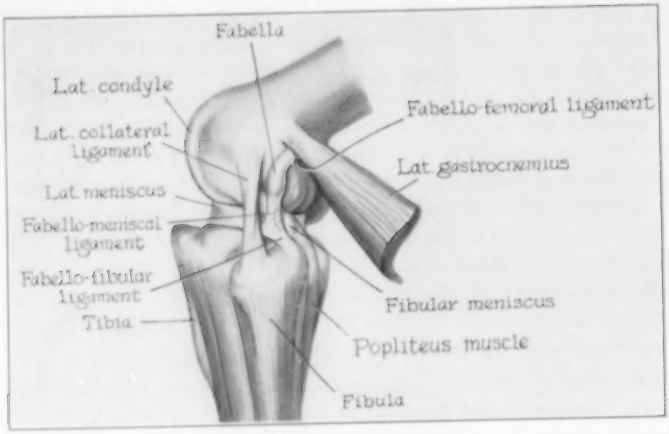


FIG. 6-A

The lateral aspect of the left knee of a kangaroo (*Macropus giganteus*). The large fabella is attached to the femur by the fabellofibular ligament with a slight extension to the lateral meniscus, which is called the fabellomeniscal ligament.

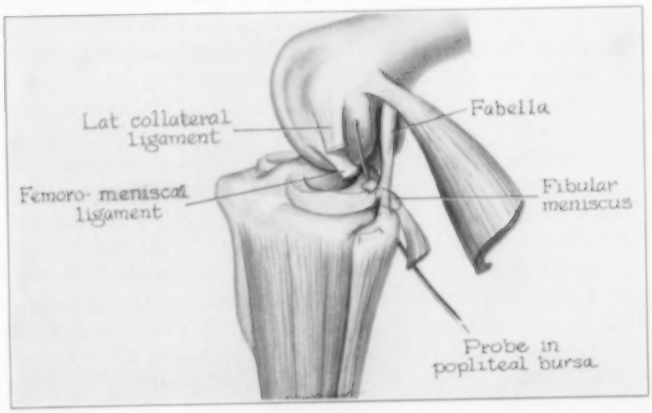


FIG. 6-B

The same knee with the lateral collateral ligament excised and the knee opened by adduction to show the fabellofibular ligament. The remnant of the meniscus between the femur and fibula can be also seen. As explained, this meniscal remnant is transformed by evolution into a direct tendon uniting the popliteus muscle with the femur.

any surgical procedure in this part of the knee joint in individuals over sixteen years of age.

Of course, the ligament may be present in younger individuals who have a cartilaginous fabella, but I had no opportunity to dissect knees of younger individuals with a cartilaginous fabella.

Non-human Knees

The morphological significance of the ligament was demonstrated with some certainty by dissections of a number of non-human specimens. Valuable contributions to the morphology of the posterior and lateral parts of the knee joint were made by Fürst, Vallois [30], Haines, and Weinberg. Fürst, in particular, was responsible for an extensive study of the popliteus tendon and muscle. His observations on amphibians, reptiles, lower mammals, and anthropoids showed that the popliteus muscle and its tendon are two independent structures that develop

separately and become connected later in the course of evolution. In the amphibians, reptiles, and birds, the knee joint consists of separate femorotibial and femorofibular joints, with a common articular cavity. There are two menisci for the femorotibial joint similar to those of the higher mammals, but there is also a separate meniscus between the femur and the fibula for the femorofibular joint. The popliteus muscle originates, in lower animals, from the fibular head and has no origin on the femur. The femorofibular meniscus, which is located between the fibular head and the femoral condyle, is held in place by two ligaments, one binding this meniscus to the femur (meniscofemoral ligament), the other binding this meniscus to the fibula (meniscofibular ligament). The point of insertion of the meniscofibular ligament on the fibular head corresponds to the origin of the popliteus muscle. The fibular head is the only point of origin of this muscle in certain lower animals.

In the course of evolution, the fibular head recedes from its contact with the femur to assume its new position at the proximal tibiofibular joint. In this descent of the fibular head, the epiphysis of the apex of the fibula may remain with the origin of the popliteus muscle and form a small ossicle in the popliteus muscle. This ossicle is found in several species and, especially, in the prosimians. Although, theoretically, such a separate ossicle might be expected to be found in the human popliteus muscle, personal investigations have not, so far, identified a single instance of the presence of this ossicle either anatomically or roentgenographically. Except for one doubtful case mentioned by Macalister (cited by Vallois [20]), there is no mention of this ossicle in the available literature.

The disappearance of the femorofibular joint in the process of evolution eliminates the functional necessity for the femorofibular meniscus and leads to its complete transformation. The two ligaments that connect it with the femur and the fibula (meniscofemoral and meniscofibular) remain unchanged; the meniscus itself undergoes a change from a fibrocartilaginous structure into a tendon that then forms a continuous structure that extends from the femur to the fibula and into the popliteus muscle. This structure becomes the tendon of the popliteus muscle, as observed in man and anthropoids and other animals. Comparative anatomy shows that there are some species in which the small ossicle persists normally in the depth of the popliteus muscle at the fibular head and that there are other species in which the popliteus muscle is attached to the fibular head by an additional tendon, as if in its descent the fibular head pulled part of the origin of the popliteus down (Fig. 5). There are other species in which the joint between the femur and fibula disappeared, but the femorofibular meniscus and the two ligaments uniting this meniscus to the femur and fibula persist.

Fürst presented overwhelming evidence based on comparative anatomy and embryology confirming the transformation of the meniscus and genesis of the popliteus tendon.

Personal observations on a representative, but, of necessity, a small group of specimens proved the veracity of Fürst's important observations concerning the popliteus muscle; my observations also permitted explanation of the morphology of the fabellofibular ligament, as observed in man.

The fabella was found to be inconstant in the anthropoids and present in the macacae, as well as in the prosimians, but no fabellofibular ligament was found.

The most interesting species for the study of the problem was the kangaroo (*Macropus giganteus*). The knee of the kangaroo has a persistent femorofibular meniscus in evolutionary recession. The small apical epiphyseal ossicle is absent at the junction of the popliteus muscle and fibular head. The meniscofemoral

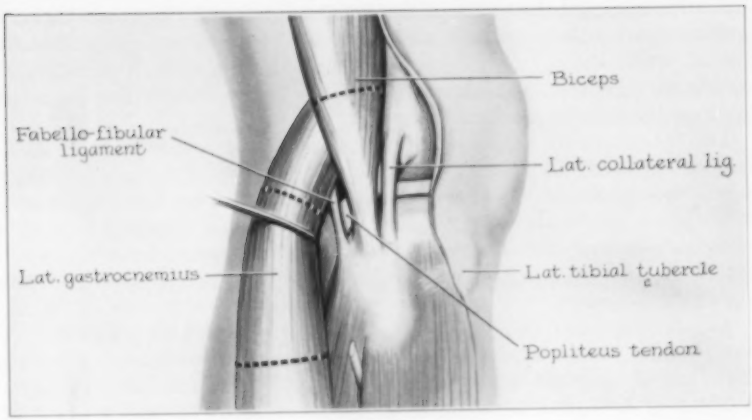


FIG. 7

Lateral view of the human right knee showing the relationship of the fabellofibular and lateral collateral ligaments to the biceps femoris tendon and body of the lateral gastrocnemius on exposure of the region. The lines of anatomical division of the muscles are indicated for deeper exposure of structures, as shown in Fig. 8.

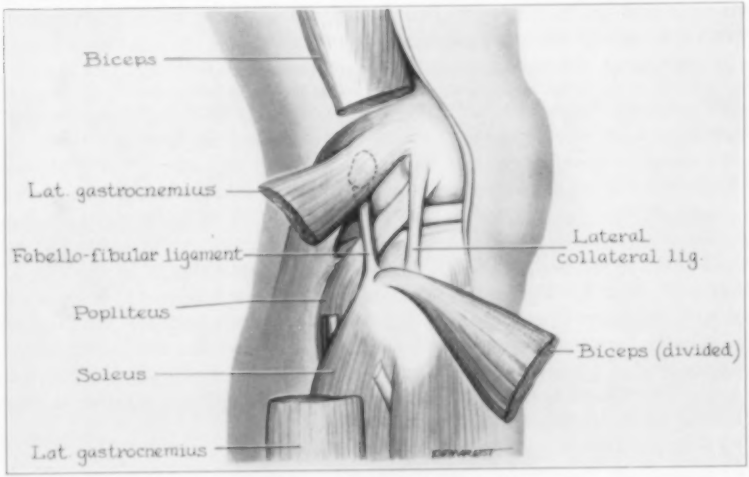


FIG. 8

Lateral view of a human right knee showing the relationship of the fabellofibular ligament and the lateral collateral ligament to the popliteus tendon on division of the gastrocnemius and biceps muscles.

and the meniscofibular ligaments are both present. Both ligaments with the femorofibular meniscus, much attenuated in size, form a structure that continues directly into the popliteus muscle, thus showing an intermediary evolutionary stage in the transformation of the femorofibular meniscus and its ligaments into the popliteus tendon, as proved by Fürst. This knee also shows a very large elongated fabella. The fabella is connected by a prominent ligament to the femur (fabellofemoral) and by another ligament (fabellofibular) to the fibula (Figs. 6-A and 6-B). With the recession of the fabellofemoral ligament and the establishment of direct contact of the fabella with the femoral condyle, this structure becomes the homologue of the human fabellofibular ligament.

The function and size of the gastrocnemius apparently have some significance in preservation of the fabellofibular ligament. This ligament is strongest in the kangaroo, where the saltatory function requires strong gastrocnemii and a strong fabellofibular ligament for greater stability of the knee during the forceful extension of the knee joint at the height of the jump.

The fabellofibular ligament may still be present in the knee joint of the human being, where the gastrocnemii are stronger than they are in other mammals in whom the stability of the knee in extension requires more ligamentous support than in other mammals. The frequent absence of this ligament in man may indicate involution. The ligament is absent in the prosimians, simians, and anthropoids, species in which the sesamoids are present, but the gastrocnemii are underdeveloped.

The fabellofibular ligament is apparently a structure in involution and is present in man when a lateral fabella is still present; in the absence of the fabella, a short lateral ligament represents a homologue of the fabellofibular ligament. The lateral arch of the arcuate ligament simply represents a reinforcement of the posterior capsule of the knee joint in the area where the popliteus muscle is attached to the coronoid ligament of the lateral meniscus and the popliteus tendon emerges from the knee joint free of the lateral meniscus, but adherent to the capsule posteriorly. The fabellofibular and, to a lesser extent, the short lateral ligament are functionally related to the stability of the knee joint. They apparently represent a fourth ligamentous structure contributing to the lateral stability of the knee joint, when the lateral gastrocnemius is stretched in extension. The other three structures contributing to the lateral stability of the knee are the lateral collateral ligament, the iliotibial tract, and the popliteus tendon and muscle (Kaplan).

In surgical procedures over the lateral side of the knee joint, the presence of the fabellofibular ligament between the tendon of insertion of the biceps and the body of the gastrocnemius may be expected if there is roentgenographic evidence of a lateral fabella. The lateral collateral ligament can be found anterior to the tendon of the biceps and about two centimeters anterior to the fabellofibular ligament (Fig. 7). The relationship of the popliteus tendon to these two structures with the knee in extension is different. The location of the insertion of the fabellofibular ligament on the fibular head corresponds to the point where the popliteus tendon turns from the fibular head into the posterior compartment of the knee. The lateral collateral ligament crosses the popliteus tendon at an acute angle near its femoral origin (Figs. 4-A, 4-B, and 8).

CONCLUSIONS

The variations in size of the short lateral ligament, the occasional absence of the short lateral ligament, and the reasons for the presence of the fabellofibular ligament are indicated in this study. The short lateral ligament and the fabellofibular ligament are apparently homologous structures corresponding to a similar strongly developed structure in the kangaroo and connected with the function of extension of the knee.

The fabellofibular ligament is apparently always present when a lateral fabella is found in man. On surgical exposure of the human knee joint, when there is roentgenographic evidence of a fabella, the fabellofibular ligament may be found as a well developed ligament. It is located just posterior to the area of insertion of the tendon of the biceps muscle, between the biceps and lateral gastrocnemius, whereas the lateral collateral ligament is located anteriorly, in front of the biceps tendon.

REFERENCES

1. Boyd, J.D.; Clark, W.E.LeG.; Hamilton, W.J.; Yoffee, J.M.; Zuckerman, Solly; and Appleton, A.B.: Textbook of Human Anatomy, pp. 235 and 237. Edited by W. J. Hamilton. London, Macmillan and Co.; New York, St. Martin's Press, 1957.
2. Cunningham, D.J.: Textbook of Anatomy, p. 368. Ed. 8. Edited by J.C. Brash and E.B. Jamieson. New York, Oxford University Press, 1943.
3. Dujarier, Charles: Anatomie des Membres; Dissection; Anatomie Topographique, p. 273. Paris, G. Steinheil, 1905.
4. Flecker, H.: Time of Appearance and Fusion of Ossification Centers as Observed by Roentgenographic Methods. Am. J. Roentgenol., **47:** 97–159, 1942.
5. Fürst, C.M.: Der Musculus Popliteus und Seine Sehne. Lund, E. Malström, 1903.
6. Gray, Henry: Anatomy of the Human Body, p. 383. Ed. 27. Edited by C.M. Goss. Philadelphia, Lea and Febiger, 1959.
7. Gruber, W.L.: Monographie über die aus wahren (hyalinischen) Cartilagines praeformirten Ossicula sesamoidea in den Ursprungssehnen der Köpfe des Musculus gastrocnemius bei dem Menschen und bei den Säugethieren. Mém. l'Acad. Impériale des Sciences de St. Petersbourg, **22** (ser. 7): 45, 1875.
8. Haines, R.W.: The Tetrapod Knee Joint. J. Anat., **76:** 270–301, 1942.
9. Henle, J.: Handbuch der Systematischen Anatomie des Menschen. Bänderlehre. Ed. 2. Vol. 1, Section 2, p. 150. Braunschweig, F. Vieweg und Sohn, 1872.
10. Hollinshead, W.H.: Anatomy for Surgeons, pp. 780–781. New York, Paul B. Hoeber Inc., 1958.
11. Kaplan, E.B.: Surgical Approach to the Lateral (Peroneal) Side of the Knee Joint. Surg., Gynec., and Obstet., **104:** 346–356, 1957.
12. Kaplan, E.B.: Factors Responsible for the Stability of the Knee Joint. Bull. Hosp. Joint Dis., **18:** 51–59, 1957.
13. Kaplan, E.B.: The Iliotibial Tract. Clinical and Morphological Significance. J. Bone and Joint Surg., **40-A:** 817–832, July 1958.
14. Kaplan, E.B.: Comparative Anatomy of the Extensor Digitorum Longus in Relation to the Knee Joint. Anat. Rec., **131:** 129–149, 1958.
15. Köhler, Alban: Borderlands of the Normal and Early Pathologic in Skeletal Roentgenology, p. 538. Ed. 10. Revised by E.A. Zimmer and translated and edited by J.T. Case. New York, Grune and Stratton Inc., 1956.
16. von Lanz, T., and Wachsmuth, W.: Praktische Anatomie. Vol. 1, pp. 4, 203, 235, and 249. Berlin, Julius Springer, 1938.
17. Last, R.J.: Some Anatomical Details of the Knee Joint. J. Bone and Joint Surg., **30-B:** 683–688, Nov. 1948.
18. Last, R.J.: The Popliteus Muscle and the Lateral Meniscus. J. Bone and Joint Surg., **32-B:** 93–99, Feb. 1950.
19. Last, R.J.: Anatomy. Regional and Applied, p. 179. Boston, Little, Brown and Co., 1954.
20. Lockhart, R.D.; Hamilton, G.F.; and Fyfe, F.W.: Anatomy of the Human Body, pp. 124 and 125 (illus.). Philadelphia, J.B. Lippincott Co., 1959.
21. Morris' Human Anatomy, p. 368. Ed. 11. Edited by J.P. Schaeffer. Philadelphia, The Blakiston Co., 1942.
22. Nomina Anatomica (Paris). Revised by the International Anatomical Nomenclature Committee, Approved in 1955. Baltimore, The Williams and Wilkins Co., 1956.
23. Paturet, G.: Traité d'Anatomie Humaine. Vol. 2, pp. 677 and 678. Paris, Masson et Cie, 1951.
24. Piersol, G.A. [Editor]: Human Anatomy, p. 402. Ed. 9. Revised by G.C. Huber. Philadelphia, J.B. Lippincott Co., 1931.
25. Rouvière, H.: Anatomie Humaine. Vol. 2, pp. 311 and 312. Ed. 5. Paris, Masson et Cie, 1943.
26. Spalteholtz, Werner: Hand Atlas and Textbook of Human Anatomy. Vol. 1, part 1, p. 200 (illus.). Ed. 15. Revised by R. Spanner. Boston, Little, Brown and Co., 1954.
27. Testut, L.: Traité d'Anatomie Humaine. Vol. 1, pp. 702–705. Ed. 8. Corrigée et augmentée par A. Latarjet. Paris, G. Doin, 1928.
28. Toldt, Carl, and dalla Rosa, A.: An Atlas of Human Anatomy for Students and Physicians. Adapted and edited by M.E. Paul. Vol. 1, p. 231, fig. 469. Ed. 2. New York, The Macmillan Co., 1928.
29. Vallois, H.V.: *In* Traité d'Anatomie Humaine, pp. 277–281. By Paul Poirier and A. Charpy. Ed. 4. Paris, Masson et Cie, 1931.
30. Vallois, H.V.: Étude Anatomique de l'Articulation du Genou Chez les Primates. Montpellier, l'Abeille, 1914.
31. Weinberg, Ernst: Recherches d'Anatomie Comparée sur l'Appareil Fibreux de la Face Postérieure du Genou. Arch. Anat. Histol. et Embryol., **9:** 253–307, 1928–1929.
32. Weitbrecht, Josias: Syndesmologia, sive Historia Ligamentorum Corporis Humani quam Secundum Observationes Anatomicas Concinnavit, pp. 142 and 262. Petropoli, Typographia Academiae Scientiorum, 1742.

The Developmental Origin of Spondylolisthesis

Two Case Reports *

BY LEWIS COZEN, M.D., LOS ANGELES, CALIFORNIA

From the Los Angeles Orthopaedic Hospital, Los Angeles

The etiology of spondylolisthesis has never been settled satisfactorily. Wiltse presented an excellent summary of the various theories that have been proposed for the etiology of this condition. Until recent years it was thought that spondylolisthesis was present at birth but did not cause pain until later in life, usually after the age of forty years. There are, however, no reported instances of the defect being demonstrated at birth. It seems probable that the defect in the pars interarticularis is formed during the period of growth.

It would be helpful, in view of the many theories concerning the cause of spondylolisthesis, to find patients whose spines were examined roentgenographically before as well as after the development of spondylolisthesis. Anderson reported one such case and cited Unander-Scharin as reporting a second. Schneider and Melamed described another illuminating case. Sullivan and Bickel have recently described three patients with traumatic spondylosis †. Two more such cases are reported here:

Patient K.M. was first seen at the age of eighteen months because of bilateral dislocation of the hips. An attempt was made to reduce the dislocations by manipulation, and, when this attempt failed, an open reduction was performed on the right hip on November 30, 1950, and on the left hip on December 6, 1950. The cast was removed on January 17, 1951. Her subsequent course was uneventful until June 27, 1956, when she returned to the clinic complaining of pain in the low back of three weeks' duration. On close questioning, no history of injury was elicited. Roentgenograms revealed the presence of typical defects in the neural arch of the fifth lumbar vertebra with spondylolisthesis at the lumbosacral interspace. A corset was prescribed, which the patient wore for about six months. By January 9, 1957, her back pain had subsided and had not returned at the time of writing.

In this case there is a series of clear lateral roentgenograms of the lumbosacral spine, beginning when the patient was eighteen months old. None of these lateral films revealed a defect in the pars interarticularis until the patient was seven and one-half years of age. Because there had been no trauma or other explanation for the development of the defect in the pars interarticularis it must be assumed that this patient has the usual type of spondylolisthesis. The defect in the pars interarticularis was not visible on the roentgenograms made to ascertain the position of the hip joints when the patient was five years of age. When the child was seven years old, progressive slipping at the lumbosacral junction started. This case adds evidence to the view that spondylolisthesis is not a congenital but a developmental anomaly.

The second patient, R.C., was studied by Dr. Joseph Risser, who saw him before the development of the defect in the neural arch and again after it had become evident. Since the patient had tuberculosis of the spine, it might be assumed that the tuberculous process had spread to a new area in the spine, and thus the spondylolisthesis was really a manifestation of the tuberculosis of the spine. However, the spondylolisthesis, as seen on the roentgenograms, is so typical that it is thought justified to consider this case as an example of an acquired defect.

* Read at the Annual Meeting of the Western Orthopedic Association, Denver, Colorado, October 21, 1959.

† Yet another case has been reported: Spondylolysis Following Spine Fusion. Report of a Case. DePalma, A. F., and Marone, P. J.: Clin. Orthop. **15: 208–211, 1959.**

FIG. 1-A

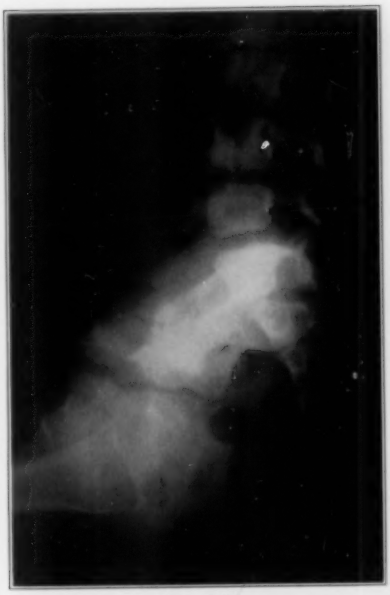


FIG. 1-B

Fig. 1-A: Case 1. When the patient was two years old, the lumbosacral spine was intact.
Fig. 1-B: When the patient was five years old, the lumbosacral spine was still intact.

FIG. 1-C

FIG. 1-D

Fig. 1-C: When the patient was seven years old she complained of back pain; the defect of the pars interarticularis at the lumbosacral spine and the forward displacement of the fifth lumbar on the first sacral vetebra are seen.
Fig. 1-D: When the patient was ten years old, further progression of the spondylolisthesis is seen.

FIG. 2-A

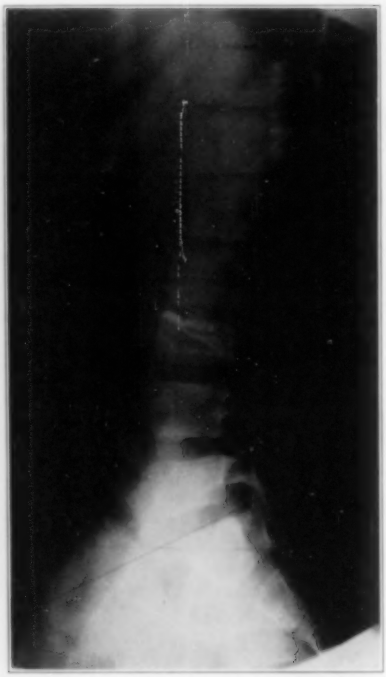


FIG. 2-B

Fig. 2-A: When the patient was eight years old he complained of back pain; he had tuberculosis of the spine, and there was destruction of the interspace between the third and second lumbar vertebrae, but the lumbosacral spine was intact.

Fig. 2-B: When the patient was nine years old there was further destruction of the interspace of the third and second lumbar vertebrae one year after fusion; the lumbosacral spine was intact.

R.C., seven years old, was first seen in 1925 because of back pain. Examination revealed a rigid and tender spine, and roentgenograms showed a destructive lesion involving the interspace between the second and third lumbar vertebrae. A spine fusion extending from the first to the fourth lumbar vertebrae was performed by Dr. Charles Yeung on July 13, 1925. When the patient was seen by Dr. Risser on July 18, 1938, a typical step-off deformity was present at the lumbosacral junction, and roentgenograms verified the clinical diagnosis of spondylolisthesis at this interspace. When the patient was seen last on January 1, 1939, he had some low-back pain, and lumbosacral fusion was recommended. However, he did not return, and attempts to locate him for follow-up have been unsuccessful.

It might be argued that the defect and spondylolisthesis in this patient were caused by the old tuberculous process in the upper lumbar spine. However, at the time the defect became manifest there was no clinical or roentgenographic evidence of tuberculosis, and there was no evidence of any inflammatory reaction at the site of this typical defect in the neural arch of the fifth lumbar vertebra. In addition, there was no evidence to suggest that this defect could have been the direct result of the surgical procedure.

THEORIES OF ETIOLOGY

The theory of separate ossification centers is now known to be fallacious. It has been definitely established that each half of the neural arch ossifies as one single center [3,6,10]. Dissections of many fetuses disclosed no separate centers of ossification or defects of the pars interarticularis [10].

The theory that this defect is produced by a birth fracture was disproved by Rowe and Roche, who could not produce a fracture through the pars inter-

FIG. 2-C

FIG. 2-D

Fig. 2-C: Two years after fusion, when the patient was ten years old, the posterior fusion was intact. (The reproduction is not so clear as the original film.)

Fig. 2-D: Thirteen and a half years after fusion, when the patient was twenty-one years old, he complained of low-back pain; the defect at the pars interarticularis of the lumbosacral spine and spondylolisthesis were present.

articularis by placing the fetus in any extreme position of flexion or extension.

Another theory suggested that the defect may be the result of non-union of fractures through the pars interarticularis during postnatal life because the incidence of this defect is nil at birth and increases with maturity [15]. However, there is no evidence to support this theory. No evidence of repair at the pars interarticularis comparable to what one would expect if this were a true fracture has been demonstrated. The rare instances of true fracture reported by Roche and by Wiltse occurred after severe trauma.

A pathological process in the pars interarticularis was also suggested as the cause of the defect [15], but no evidence of avascular necrosis or other abnormality has been disclosed. Bosworth and associates found thin tenuous fibrous bands at the defect, a false joint, thick fibrous tissue, or a bone bridge across the area where the defect had been suspected.

Excessive lumbar lordosis has also been proposed as a cause of the defect. Stewart found increased lumbar lordosis in Eskimo skeletons with spondylolisthesis, but Bosworth and associates could demonstrate no correlation between the two factors in their cases.

Weakness of the supporting structures as a causative mechanism was suggested by Newman, but no evidence has been adduced to support this theory. There is no increased evidence of the condition in poliomyelitis, nor is there evidence that the muscles or ligamentous structures are defective in people who have spondylolisthesis.

Non-union of a stress fracture would appear to be a plausible explanation

for the presence of the lesion during or after childhood—a time of life when stress has been severe. With no immobilization of the back, and the severe stresses in the lumbar region far in excess of those on other bones where stress fractures usually occur, one would not expect callus to form. Bosworth and associates actually did find instances in which a bone bridge was present in the pars articularis where a defect was thought to be present before operation.

Congenital weakness of the pars interarticularis would appear to be a factor in the causation of spondylolisthesis, as shown by Wiltse and his studies of the families of patients with spondylolisthesis. Stewart's finding of a high incidence of the lesion in Eskimos is also consistent with this concept. The only difficulty with this theory is that no congenital abnormality of the pars interarticularis has been demonstrated that could be considered as predisposing to lysis of the pars interarticularis.

Willis observed that the defect at the pars interarticularis in spondylolisthesis is not found in other primates or in human fetal skeletons. He believed that this defect was related to the upright posture or to some human custom of handling infants while the spine is still largely cartilaginous.

Adkins noted at surgery that the width of the laminal defect in some cases is much less than the amount of slipping of the vertebral bodies. This discrepancy appeared to result from elongation of the posterior part of the isthmus. He concluded from this observation that in these cases the defects and the slipping must have been present at a very early stage of skeletal development. He mentioned the probability that the lesion is of developmental origin, since there were two cases with lesions at two levels, and spina bifida was present in three other cases.

SUMMARY

Two cases are presented in which spondylolisthesis was a developmental defect of the spine and was not present at birth. Serial roentgenograms of these two patients show an intact neural arch during childhood followed by the presence of typical spondylolisthesis later in childhood.

REFERENCES

1. Adkins, E. W. O.: Spondylolisthesis. J. Bone and Joint Surg., **37-B:** 57–62, Feb. 1955.
2. Anderson, C. E.: Spondyloschisis Following Spine Fusion. J. Bone and Joint Surg., **38-A:** 1142–1146, Oct. 1956.
3. Batts, Martin, Jr.: The Etiology of Spondylolisthesis. J. Bone and Joint Surg., **21:** 879–884, Oct. 1939.
4. Bosworth, D. M.; Fielding, J. W.; Demarest, Lawrence; and Bonaquist, Mario: Spondylolisthesis. A Critical Review of a Consecutive Series of Cases Treated by Arthrodesis. J. Bone and Joint Surg., **37-A:** 767–786, July 1955.
5. Gill, G. G.; Manning, J. G.; and White, H. L.: Surgical Treatment of Spondylolisthesis without Spine Fusion. Excision of the Loose Lamina with Decompression of the Nerve Root. J. Bone and Joint Surg., **37-A:** 493–520, June 1955.
6. Hitchcock, H. H.: Spondylolisthesis. Observations on Its Development, Progression and Genesis. J. Bone and Joint Surg., **22:** 1–6, Jan. 1940.
7. Newman, P. H.: Sprung Back. J. Bone and Joint Surg., **34-B:** 30–37, Feb. 1952.
8. Roche, M. B.: Bilateral Fracture of the Pars Interarticularis of a Lumbar Neural Arch. J. Bone and Joint Surg., **30-A:** 1005–1008, Oct. 1948.
9. Roche, M. B.: The Pathology of Neural-Arch Defects. A Dissection Study. J. Bone and Joint Surg., **31-A:** 529–537, July 1949.
10. Rowe, G. G., and Roche, M. B.: The Etiology of Separate Neural Arch. J. Bone and Joint Surg., **35-A:** 102–110, Jan. 1953.
11. Schneider, C. C., and Melamed, Abraham: Spondylolysis and Spondylolisthesis. Case Report Clarifying the Etiology of Spondylolysis. Radiology, **69:** 863–866, 1957.
12. Stewart, T. D.: The Age Incidence of Neural-Arch Defects in Alaskan Natives Considered from the Standpoint of Etiology. J. Bone and Joint Surg., **35-A:** 937–950, Oct. 1953.
13. Sullivan, C. R., and Bickel, W. H.: The Problem of Traumatic Spondylosis. A Report of Three Cases. Am. J. Surg., **100:** 698–708, 1960.
14. Willis, T. A.: Man's Back, p. 38. Springfield, Illinois, Charles C. Thomas, 1953.
15. Wiltse, L. L.: Etiology of Spondylolisthesis. Clin. Orthop., **10:** 48–59, 1957.

Ewing's Sarcoma

A Critical Analysis of 165 Cases

BY DAVID C. DAHLIN, M.D., MARK B. COVENTRY, M.D., AND PAUL W. SCANLON, M.D., ROCHESTER, MINNESOTA

From the Section of Surgical Pathology, the Section of Orthopaedic Surgery, and the Section of Therapeutic Radiology, Mayo Clinic and Mayo Foundation, Rochester

In 1921 Ewing described a type of malignant tumor of bone which he believed to be different from other tumors of bone as distinguished up to that time. Because the nature of the parent cell is still in marked dispute, the eponym *Ewing's* must still remain to distinguish this specific entity.

The clinical picture of this tumor is well known[5,6]. Briefly, it is a highly malignant primary tumor of bone occurring chiefly in the second decade of life and attacking almost any bone. In the major tubular bones, any portion may be involved; and the lesion often is extensive. It produces pain or swelling or both. Characteristically, the patient appears to be ill, with low-grade fever, moderate leukocytosis, and sometimes secondary anemia; but there are many exceptions to this picture.

Whereas in the past the roentgenographic appearance was considered to be relatively pathognomonic, characterized by osteolysis without osteosclerosis and by an onion-skin layering of subperiosteal new bone, it is now known that the picture is extremely variable and not specific. Many of the lesions contain zones of sclerosis. Radiating spicules from the cortex of an affected bone are not uncommon. Several other malignant tumors can mimic the appearance of Ewing's sarcoma, as may eosinophilic granuloma and osteomyelitis. Although the diagnosis may be strongly suspected on clinical and roentgenographic grounds, it will depend ultimately upon microscopic study.

In 1957 we presented a critical analysis of 430 cases of osteogenic sarcoma verified by study at the Mayo Clinic[1]. We wish now, similarly, to present our cases of Ewing's tumor, each of which has been currently reviewed histologically by one of us (Dahlin). The records, roentgenograms (when available), and follow-up data have been reviewed by the three authors. Other reports of Ewing's tumors have come from the Mayo Clinic[7,8], but at this writing an appreciably larger number of cases are now available for study. This has given added perspective, allowed longer periods of follow-up, and given increased statistical significance to our data, especially in respect to survival of patients who have this highly malignant lesion.

Pathological Aspects

The pathologist regards Ewing's tumor somewhat differently today than he has in the past. For many years after the original description in 1921, a variety of primary and secondary neoplasms, as well as some non-neoplastic conditions affecting bone, were more or less casually listed as Ewing's tumors[10]. The common denominator of this diverse group was a generous component of small, round cells. The past three decades have brought about remarkable enlightenment concerning osseous lesions, with the result that metastatic tumors, leukemic infiltrates, various forms of malignant lymphoma (including reticulum-cell sarcoma), myeloma, eosinophilic granuloma and its clinical variants, and even

some osteogenic sarcomata with unusually small cells have been removed from the category of Ewing's sarcoma. Vastly differing pathological and clinical implications demand such distinction.

Ewing's sarcoma, in the light of current knowledge, may be defined as a highly anaplastic, malignant, small round-cell tumor which clinically is primary in bone (Fig. 1-A). The other primary osseous lesions just mentioned, the cells

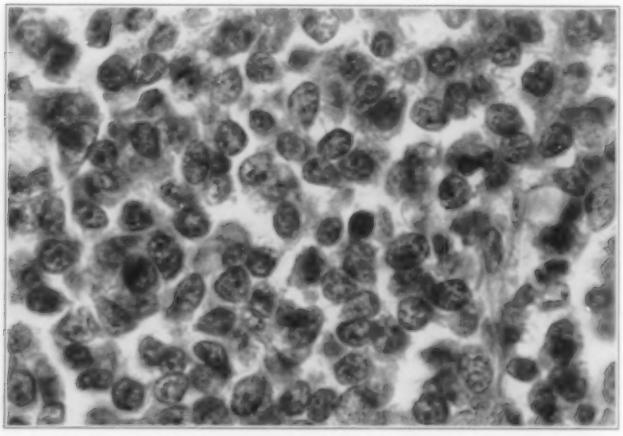


FIG. 1-A

Typical Ewing's sarcoma with small nuclei that are regular in size and shape (hematoxylin and eosin, × 800).

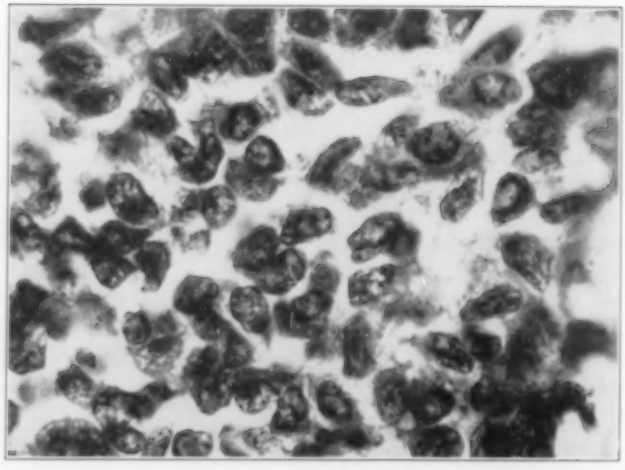


FIG. 1-B

Ewing's sarcoma with slightly larger and somewhat irregular cells (hematoxylin and eosin, × 800). (Reproduced by permission from Dahlin, D.C.: Bone Tumors. General Aspects and an Analysis of 2,276 Cases. Springfield, Illinois, Charles C. Thomas, 1957.)

of which contain nuclei that are small and round, ordinarily are readily recognized histologically. Occasional highly malignant tumors are observed in which the size and morphological characteristics of the nuclei are intermediate between those of Ewing's sarcoma and those of reticulum-cell sarcoma (Fig. 1-B). In the

current group of 165 Ewing's sarcomata, there were twenty-two such lesions with cells somewhat larger than those of the remaining 143 tumors. These were clinically and prognostically so similar to the over-all group that it seemed useless to place them in a distinct category. To emphasize this similarity further, some variation in cell size was encountered within different portions of several of the Ewing's sarcomata. We found no evidence that tumors of this somewhat atypical type should be listed with the malignant lymphomata. The diagnosis of malignant lymphoma, including reticulum-cell sarcoma, should be restricted to those tumors which have cytologic features indicating firmly that they belong in this category.

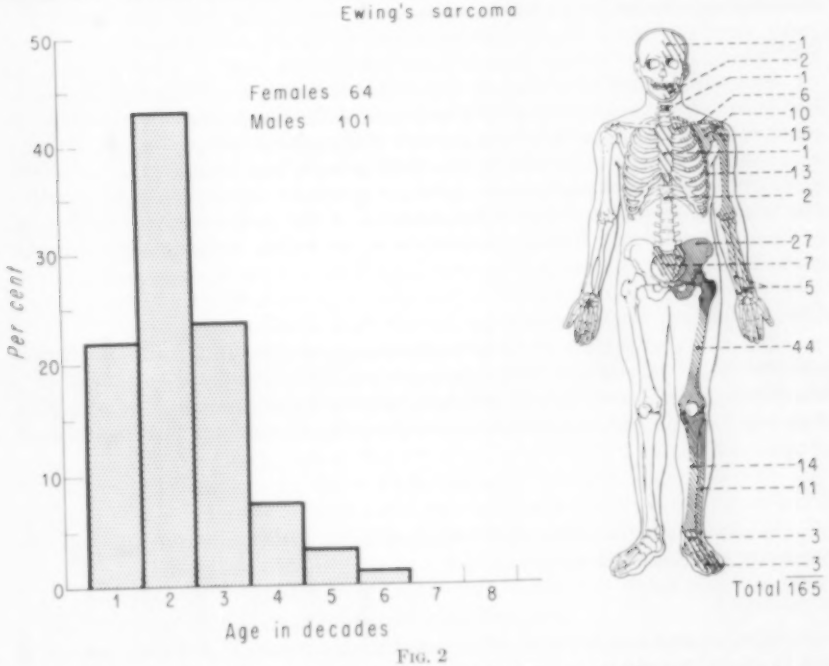


FIG. 2

Distribution according to age and sex and skeletal distribution of 165 Ewing's sarcomata seen at the Mayo Clinic prior to January 1, 1960. The regions of predilection are indicated by the density of the cross-hatching.

In rare instances it is impossible to determine clinically or by biopsy whether a given small round-cell malignant tumor of bone is primary or is the result of metastasis from an obscure lesion situated elsewhere. This problem may be compounded by the tendency of Ewing's sarcoma to metastasize to other bones. In our experience it has been extremely unusual for a metastatic process to simulate, clinically and pathologically, Ewing's sarcoma. If the issue whether or not the tumor is primary in bone is in doubt after thorough study of the patient, the local osseous lesion must be treated as if it were the primary problem: Ewing's sarcoma. Long deliberation or procrastination until the results of necropsy decide the issue are obviously out of the question.

Ewing's sarcoma is often a soft tumor because it usually lacks appreciable stroma. It cannot be distinguished safely from other tumors or even from inflammatory processes by gross examination. The small cells of Ewing's sarcoma characteristically occur in large islands which contain little or no connective tissue,

even at the level of stainable reticulin fibers. Because of the readily available descriptions of Ewing's sarcoma and of the lesions which may simulate it [2,5,6], these features will not be detailed here. Since these tumors are so anaplastic that the cell origin is not even known, they are all Grade 4 when appraised by the method of Broders.

PRESENT STUDY

This group of 165 patients with Ewing's sarcoma was seen at the Mayo Clinic from 1905 to January 1, 1960. The group comprises somewhat less than 10 per cent of the total number of patients with primary malignant tumors affecting bone in the Mayo Clinic series.

Location

The distribution according to site of involvement is indicated in Figure 2. The pelvic girdle and the long tubular bones of the extremities were the sites of approximately three-fourths of the tumors. Although it is often said that Ewing's sarcoma characteristically affects the diaphysis of long tubular bones, in our series the metaphyseal regions were more commonly the epicenters of the growths. The relative immunity of the distal portions of the extremities is accentuated by the absence of any Ewing's sarcomata in the hands, although four occurred in the feet.

Age

The youngest patient was a girl eighteen months old with a femoral tumor, and the oldest was a man fifty-nine years old with primary involvement of a rib. The distribution of ages of patients, by decades, at the time of diagnosis is shown in Figure 2. Almost 90 per cent of the patients were less than thirty years of age.

Sex

As is usual in the case of Ewing's sarcoma, males predominated; in this series, by a ratio of 101 to 64.

Treatment

Some of the controversial ideas concerning treatment of Ewing's sarcoma are indicated by the management of various patients in our series. Irradiation therapy, amputation, local excision, curettage, and Coley's toxins have been employed in a wide variety of combinations. Irradiation has been directed at the local lesion, at regional nodes, and at pulmonary and other metastatic deposits. In two instances metastatic deposits were removed from the lung.

These cases cannot easily be placed in distinct categories of treatment because of the great variety of treatment employed. After review of the histories, however, it was concluded that of seventy-nine patients with sarcomata in the extremities treated before 1955, forty-eight received irradiation as the first definitive therapy and eighteen underwent amputation as the first therapeutic measure. Of fifty-six patients with sarcomata elsewhere than in the extremities, in the same period, forty-two received irradiation as the first definitive treatment and one, who had a scapular tumor, underwent amputation as the first measure. The patients not treated by irradiation or amputation were treated by such procedures as local excision, drainage, scrapings, and the administration of Coley's toxins. Biopsy with no treatment was performed on some. Many of these patients subsequently received irradiation, and a few underwent amputation. The original treatment in

this total series was administered in a variety of places, although in the vast majority it was carried out at the Mayo Clinic.

COMMENT

We have computed the generally accepted five and ten-year survival periods from the dates of histological confirmation of the diagnosis. The over-all figures are based on all patients treated before January 1, 1955, regardless of the form of therapy employed or the location and extent of the lesions. One hundred and thirty-five patients of the total were eligible, on the foregoing basis, for five-year study, and we have data concerning 133 of these—two having been lost to follow-up study. Twenty (15 per cent) of those whose condition was followed survived five years. The details of treatment and results in these twenty cases are given in Table I. Two others survived five years after roentgen therapy had been administered for bone tumors clinically diagnosed as Ewing's sarcoma. In one of these, histological confirmation was obtained four years after the first treatment and death occurred slightly more than a year later. In the other, confirmation was obtained five years after the first treatment and the patient was alive two years later with "arrested" disease, even though pulmonary nodules, presumed to be metastatic, had been irradiated. These last two patients are not included in the survival data.

Ten-year survival studies were applicable to 114 patients, but two of these (the same two just indicated) have been lost to follow-up inquiry. Twelve (10.7 per cent) of 112 whose condition was followed, survived ten years. Almost identical results were reported by Wang and Schulz in 1953.

These survival data are misleadingly optimistic, because six of the twenty patients who lived five years after the diagnosis had been made have died from the effects of Ewing's sarcoma. Three of these died in the sixth year of follow-up study, one in the seventh, one in the eleventh, and one in the twelfth year. If those who died shortly after the periods indicated are subtracted, the five and ten-year survival rates are then 12 and 9 per cent, respectively. Similarly, delayed deaths were observed by Wang and Schulz. The highly lethal character of Ewing's sarcoma is further emphasized by the fact that ninety-five of the 133 patients on whom five-year survival rates were based died within two years from the time of diagnosis, and fifty-nine of these died in the first year.

The primary definitive treatment administered to eleven of the twenty who survived at least five years was irradiation. Three of these eleven (Cases 1, 10, and 16) underwent amputation for recurrent tumors three, four, and eleven years after the irradiation. In Case 10 the amputation was performed for palliation shortly before death, and in Case 16 irradiation was administered for presumed pulmonary metastases which developed after the amputation. Seven of the twenty underwent amputation as the primary definitive treatment (Cases 3, 7, 11, 15, 17, 18, and 19). In two of these, procedures deemed by us to have been non-definitive preceded the amputation; in Case 3 amputation was delayed four months because results of the original biopsies were inconclusive, and in Case 19 arthrodesis had been performed elsewhere two years before recurrence and proper recognition of the sarcoma led to amputation. Two patients had undergone excision of the entire primary lesion as the first definitive treatment (Cases 2 and 20). In Case 20 irradiation was required for recurrence two years and five months after excision of a tumor of the rib. In Case 2 ancillary irradiation was administered after wide local excision of a tumor of the clavicle.

The location of the tumors in those who survived five or more years also is shown in Table I. Six were located in bones not of the extremities proper. These

TABLE I

EWING'S SARCOMA: PATIENTS SURVIVING MORE THAN FIVE YEARS

Case	Bone	Age at Diagnosis (*Years*)	Primary Procedure	Additional Procedures (*Months* after Primary Procedures)	Years since Primary Treatment	
					Dead	Living
1	Humerus (upper third)	23	Curettage, grafting, irradiation	Sequestrectomy 20 mos.; amputation (disarticulation at shoulder) 32 mos.		39
2	Clavicle (medial third)	21	Excision (complete), irradiation		33	
3	Fibula (upper third)	6	Biopsy	Biopsy 2 mos.; biopsy 3 mos.; amputation above the knee 4 mos.; irradiation (thigh and groin) 4 mos.; irradiation (lungs) 17 mos.		32
4	Femur (upper third)	11	Biopsy, irradiation			26
5	Femur (upper third)	12	Biopsy, irradiation	Irradiation (lungs) 6 mos.	22	
6	Ilium	36	Biopsy, irradiation	Irradiation (at home 2 yrs. prior—clinical diagnosis of tumor); irradiation (lungs) 48 mos.	5.5*	
7	Humerus (lower half)	5	Biopsy, amputation			26
8	Ilium	36	Biopsy, irradiation		10*	
9	Scapula	24	Biopsy, irradiation	Irradiation 44 mos.; irradiation 58 mos.	5*	
10	Femur (lower third)	39	Biopsy, irradiation	Biopsy, irradiation 15 mos.; amputation for Ewing's tumor 119 mos.	11*	
11	Femur (upper third)	31	Amputation (disarticulation at hip), irradiation (groin)			18
12	Femur (upper fourth)	25	Curettage, irradiation	Irradiation 2 mos.		16
13	Mandible	13	Biopsy, irradiation			17
14	Radius (lower third)	11	Irradiation	Excision, grafting 0.3 mos.; grafting (ununited fracture) 13 mos.		15
15	Femur (middle third)	50	Amputation (junction middle and upper thirds of femur)		6.5*	
16	Femur (upper third)	18	Biopsy, irradiation	Irradiation multiple times; amputation hindquarter) 48 mos.; irradiation (lungs) 50 and 52 mos.		6
17	Metatarsal	11	Biopsy, amputation (below the knee)			5
18	Fibula (middle third)	6	Biopsy, amputation (above the knee)			5
19	Navicular (tarsal)	17	Arthrodesis	Amputation 24 mos. (below the knee)		6
20	Rib (fourth)	19	Excision (complete)	Irradiation 28 mos.; irradiation (lungs) 29 and 45 mos.; irradiation (pelvis) 50 mos.	5.3*	

* Died of Ewing's sarcoma.

six included four of the six tumors which ultimately produced death of the patients. Seven of the long-term survivors had Ewing's sarcoma of the femur, and five of these tumors had affected the upper portion of that bone.

The ages, at the time of diagnosis, of those who survived more than five years also are shown in Table I. There is a mere suggestion that the older patients had a better prognosis.

Is irradiation the preferred treatment for Ewing's sarcoma? Our data do not warrant a decisive opinion, but there is a suggestion that ablative surgical treatment is more efficacious. As just indicated, nearly 83 per cent of the patients received irradiation as the primary definitive therapy, but primary amputation was performed for 35 per cent of the five-year survivors. In addition, three of those treated first by irradiation subsequently required amputation because of recurrence. Additional doubt is cast on the value of irradiation by the fact that four of the six patients who died late from Ewing's sarcoma had received this form of treatment primarily.

Irradiation was of great value as a palliative measure both for the primary lesions and for metastatic deposits. Such treatment of metastatic pulmonary deposits apparently contributed to the survival of five of the patients listed in Table I. Although two of these subsequently died of the tumors, two others survived more than twenty years after such therapy. The presumed metastatic foci in these five cases were not verified histologically. Others [4,7,11] have observed long survival of patients after treatment of pulmonary metastasis from Ewing's sarcomata.

Surgical therapy for metastatic processes rarely has seemed feasible. It was employed in only two patients in the present series. Gratifyingly, one of these patients was alive and well three years and six months after resection of the right lower pulmonary lobe for a metastatic nodule one centimeter in diameter which appeared twenty months after disarticulation at the shoulder for Ewing's sarcoma involving the lower three-fourths of the left humerus. Although this patient has now survived for five years, she is not included in the statistical survey because her first operation was in January 1955. Harrison reported on a patient who had survived more than five years after removal of two pulmonary nodules, although roentgen therapy was necessary for a pulmonary hilar mass in the interim. Another patient with Ewing's sarcoma of the humerus in our series was treated by irradiation, and seven months later a pulmonary metastatic process developed which was excised. She died, however, of generalized metastases about a year later.

The technique and type of irradiation employed in this series varied markedly because some of the patients were treated several decades ago and because several radiotherapists were involved. Although the number of patients treated by various methods is not large enough to permit unchallengeable conclusions, our data do not indicate that present-day conventional fractionated roentgen therapy or cobalt teletherapy is superior to the older and now discarded intensive erythema-dose technique. In fact, the best results from irradiation were obtained in thirty-nine patients treated by the complete erythema-dose technique in which two or more series were employed. The details of irradiation and its results will be amplified in a later communication by two of us (Scanlon and Coventry).

Ewing's sarcoma has a marked tendency to metastasize to bones and to involve other portions of the bone in which it is primary. For these reasons consideration should be given to the treatment of the entire bone in which the lesion originates, if reliance is placed upon radiotherapy.

Coley's toxins did not appear to be of conclusive value, although they were

administered to a number of patients in this series. Perfusion of the tumor-bearing area or systemic chemotherapy might be considered as ancillary therapy, particularly in view of the high incidence of the hematogenous spread of Ewing's sarcoma. In an occasional case we have employed radioactive phosphorus for its generalized effect at the time of primary therapy, in an effort to prevent the development of metastasis. This technique has not been employed long enough to permit us to form conclusions about its effectiveness.

SUMMARY

Ewing's sarcoma is an entity among the malignant neoplasms of bone. Death can result from this tumor after many years, although the lesion usually produces death within two years after diagnosis. Despite the usually lethal effect of Ewing's sarcoma, nearly 10 per cent of patients affected can be cured. Our data indicate that irradiation, ablative surgical treatment, or combinations of these can be curative. In the case of tumors of the extremities, amputation with or without preoperative irradiation appears to be the treatment of choice, but the evidence is not overwhelming. Patients who have metastatic processes sometimes can be cured by appropriate irradiation or surgical therapy.

REFERENCES

1. Coventry, M. B., and Dahlin, D. C.: Osteogenic Sarcoma. A Critical Analysis of 430 Cases. J. Bone and Joint Surg., **39-A:** 741–757, July 1957.
2. Dahlin, D. C.: Bone Tumors. General Aspects and an Analysis of 2,276 Cases, pp. 156–163. Springfield, Illinois, Charles C. Thomas, 1957.
3. Ewing, James: Diffuse Endothelioma of Bone. Proc. New York Pathol. Soc., **21:** 17–24, 1921.
4. Harrison, H. N.: Ewing's Sarcoma: Ten-Year Survivals. Report of a Case With Recurrent Pulmonary Metastases. Ann. Surg., **148:** 783–789, 1958.
5. Jaffe, H. L.: Tumors and Tumorous Conditions of the Bones and Joints. Philadelphia, Lea and Febiger, 1958.
6. Lichtenstein, Louis: Bone Tumors. Ed. 2. St. Louis, The C. V. Mosby Co., 1959.
7. McCormack, L. J.; Dockerty, M. B.; and Ghormley, R. K.: Ewing's Sarcoma. Cancer, **5:** 85–99, 1952.
8. Meyerding, H. W.: The Diagnosis and Treatment of Ewing's Tumor (Endothelial Myeloma; Solitary Diffuse Endothelioma; Hemangio-endothelioma). Trans. Western Surg. Assn., **48:** 183–208, 1938.
9. Wang, C. C., and Schulz, M. D.: Ewing's Sarcoma. A Study of Fifty Cases Treated at the Massachusetts General Hospital, 1930–1952 Inclusive. New England J. Med., **248:** 571–576, 1953.
10. Willis, R. A.: Pathology of Tumours, pp. 686–687. London, Butterworth and Co., Ltd., 1948.
11. Winham, A. J.: Ewing's Tumor of a Rib with Pulmonary Metastasis. Report of a Case with Ten-Year Survival. Am. J. Roentgenol., **71:** 445–447, 1954.

Acute Arterial Injuries Due to Blunt Trauma

BY HAROLD A. COLLINS, M.D., AND J. KENNETH JACOBS, M.D.,
NASHVILLE, TENNESSEE

From the Department of Surgery, Vanderbilt University Medical Center, Nashville

Acute arterial injuries are recognized with increasing frequency as an important complication of blunt trauma. Such injuries may cause several pathological lesions and may involve visceral as well as peripheral arteries. The incidence of major arterial damage associated with non-penetrating trauma is difficult to determine. Arterial insufficiency under these circumstances may not be perceived or its presence may be attributed to other conditions. Arterial injury secondary to penetrating wounds is far more common but among 136 patients with acute arterial injuries Morris and associates reported nine injuries that were apparently due to blunt trauma [8]. The severity of such injuries was emphasized by Couves and his associates. They reported seven patients with acute arterial injuries in association with fractures of the lower extremity; gangrene developed in six of these limbs on which immediate operation was not performed.

Striking progress has occurred in the surgical management of acute arterial injuries after penetrating wounds. During World War II arterial suture was performed in only eighty-one cases in the entire series of 2,471 arterial wounds reported by De Bakey and Simeone. The amputation rate in World War II was 40.3 per cent. During the Korean War arterial repair was performed more frequently and the amputation rate after repair of major arteries declined to 13 per cent [4]. This improvement resulted from better surgical management and a more aggressive approach to vascular injuries. In civilian practice normal pulsatile flow has been restored in as many as 86 per cent of patients with acute arterial injuries in whom repair was attempted[5].

Similar progress has not been achieved in the management of arterial injuries due to blunt trauma. This deficiency results from a less aggressive treatment and from failure to appreciate the true nature of the lesion. The purpose of this report is to emphasize the importance and frequency of arterial injuries incurred by blunt trauma and to suggest immediate surgery for restoration of arterial flow. Our experience with twelve patients with arterial damage due to blunt trauma is described.

SITE AND MECHANISM OF ARTERIAL INJURY

The peripheral arteries are particularly vulnerable to injury by blunt trauma. The arteries of the extremities were involved in nine of the twelve arterial injuries in the series (Fig. 1 and Table 1). This corresponds to the greater incidence of trauma to the extremities. Because of their exposed location and immediate proximity to bone the brachial and femoral arteries are especially vulnerable. The peripheral arteries are more prone to injury by blunt trauma, but the visceral arteries and aorta are occasionally affected. In one patient in this series, a fall from a bicycle resulted in laceration of a renal artery and, in another, thrombosis of a renal artery occurred after the patient fell from a tree. In most instances the trauma responsible for arterial injuries was moderately severe. Fractures or dislocations were the chief associated injuries of major importance.

The mechanism of arterial injury due to blunt trauma would appear to

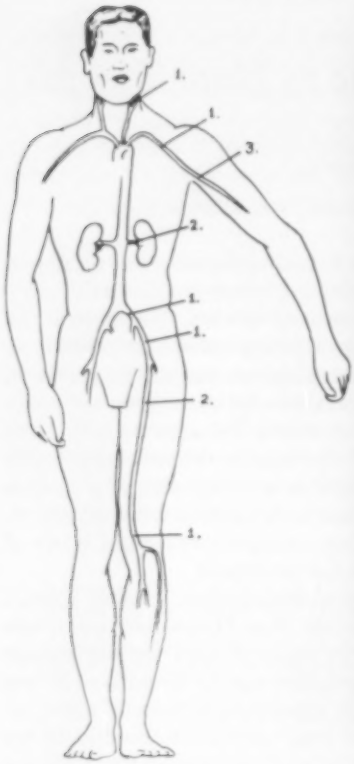


FIG. 1

FIG. 2

Fig. 1: Diagram of anatomical distribution of arterial injuries secondary to blunt trauma encountered in twelve patients.

Fig. 2: Operative femoral arteriogram demonstrating occlusion of the distal superficial femoral artery in Case 10.

FIG. 3

Thrombotic occlusion of an artery produced by fracture of the intima. A similar injury produced obstruction of the brachial artery in Case 4.

consist in one of the following: (1) direct laceration or angulation of the artery caused by the fragments of a fracture; (2) contusion or laceration of the artery as a direct consequence of trauma; and (3) sudden forceful motion of a mobile organ causing rupture of the artery at its origin where the vessel is more or less fixed. The last mechanism is especially important in production of injury to visceral

TABLE I

A Tabulation of Twelve Cases of Arterial Injury Due to Blunt Trauma

Case	Site	Lesion	Time Lag	Treatment	Result *
1. B.T.	Ext. carotid	False aneurysm	3 weeks	Resection	Excellent
2. H.H.	Axillary	Thrombosis	18 hours	Vasodilators	Fair
3. L.G.	Brachial	Laceration	4 hours	Anastomosis	Excellent
4. R.O.	Brachial	Thrombosis	4 hours	Teflon graft	Excellent
5. A.J.	Brachial	Thrombosis	2 months	Sympathectomy	Fair
6. R.P.	Renal	Thrombosis	4 days	Nephrectomy	Excellent
7. R.N.	Renal	Laceration	2 hours	Nephrectomy	Excellent
8. W.P.	Common iliac	Laceration	6 hours	Anastomosis	Died: assoc. injuries
9. J.P.	Ext. iliac	Thrombosis	6 hours	Homograft	Excellent
10. J.C.	Sup. femoral	Thrombosis	4 months	Homograft	Excellent
11. J.M.	Sup. femoral	Thrombosis	8 hours	Homograft	Excellent
12. R.S.	Popliteal	Laceration	2 days	Teflon graft	Gangrene

* Patients with no symptoms or limitation are considered to have an excellent result; those with continuing symptoms or limitation are considered to have a fair result.

arteries and apparently accounted for the two renal arterial injuries in this series. Occasionally, trauma causes incomplete rupture of an artery or fracture of the intima. Complete arterial occlusion may be produced as the result of a traumatic circumferential intimal fracture[3,7] (Fig. 3). This type of injury was responsible for occlusion of the brachial artery in Case 4.

DIAGNOSIS

Non-penetrating injuries to the arteries of the extremities produce a characteristic and easily recognized syndrome of distal ischemia. The absence of arterial pulsation distal to the site of blunt trauma in association with a cool, pallid, hypesthetic extremity is indicative of acute arterial occlusion. The syndrome is usually noted but too frequently is ascribed to arterial spasm or extrinsic compression by a hematoma or cast. Prolonged observation with the expectation that improvement will occur results in irreversible ischemic changes. This policy in Case 12 resulted in gangrene of the leg.

In our experience arterial spasm very rarely produces this syndrome. In the presence of an enlarging hematoma, extrinsic compression by a cast may produce arterial insufficiency; but this is usually quickly relieved after removal of the cast. Failure of circulatory improvement after removal of the cast is presumptive evidence of arterial occlusion and operation is warranted. Occasionally, angulation of an artery by displaced fracture fragments produces obstruction by compression, but pulses should return after adequate reduction.

Arteriography has become increasingly valuable as a means to establish the diagnosis and to define the site and extent of injury [6] (Fig. 2). No delay in operation is necessary since the procedure can be employed in the operating room immediately prior to or coincident with operation. On occasion, it is possible to combine arteriography with the initial roentgenographic examination of the fracture. Arteriography has not been used routinely in our experience but it has been employed frequently for localizing the site and extent of injury.

Diagnosis of visceral arterial injury due to non-penetrating trauma is usually more difficult. Renal arterial thrombosis was diagnosed in one case after two intravenous pyelograms, performed because of hematuria, failed to demonstrate function of the left kidney. Evidence of massive intra-abdominal bleeding in another patient led to operation, at which time a lacerated renal artery was found.

Exploratory operation is justified in any case if a diagnosis cannot be satisfactorily established by other methods. The risk of operation or the danger of infection is insignificant in comparison with the risk of a gangrenous limb.

TREATMENT

An aggressive therapeutic approach is necessary for arterial injuries due to blunt trauma if ischemia or complications resulting from hemorrhage are to be avoided. In general, immediate operation is indicated when the patient's condition permits. Occasionally, severe associated injuries may take precedence in treatment but arterial continuity must be restored before irreversible ischemia occurs.

Temporizing measures, such as sympathetic blocks and the administration of vasodilators or anticoagulants, have little to commend them and serve only to delay definitive diagnosis and therapy. The value of sympathetic blocks in arterial spasm has been overemphasized. Furthermore, Kinmonth, Simeone, and Perlow showed that traumatic spasm of large arteries is not under sympathetic control. While non-operative therapy occasionally results in a viable limb, chronic ischemic symptoms are frequent. With increasing experience it has become apparent that permanently satisfactory functional results can only be achieved by the restoration of normal pulsatile blood flow to the extremity.

In general, the arterial injury in the acute stage can be managed by resection of the involved arterial segment. It is frequently possible to restore arterial continuity by direct anastomosis. If undue tension prevents performance of an adequate anastomosis an arterial synthetic graft or venous autograft of appropriate size should be used. Concomitant injury to major venous channels should also be repaired since occasionally massive venostasis may lead to loss of a limb. When a visceral artery is lacerated, it may be possible to re-establish arterial continuity, although nephrectomy was performed for the patients in this series.

In this series of twelve patients with arterial injury due to blunt trauma the diagnosis was established and therapy instituted within twenty-four hours in seven of the patients (Table I). In five of the six patients who had injuries to major vessels supplying the extremities, normal pulsatile flow was returned to the affected extremity by direct arterial surgery. The sixth patient (Case 8) died as the result of severe associated injuries. One patient (Case 2) with traumatic thrombosis of the axillary artery was treated merely by the administration of vasodilators. Gangrene did not develop but this patient continues to have ischemic symptoms referable to the arm.

In the remaining five patients surgical treatment of the arterial injury was not instituted until after twenty-four hours had elapsed. In every instance surgical therapy eventually became necessary either because of irreversible tissue necrosis or symptoms referable to the arterial lesion. It is apparent that delay in surgical therapy has little virtue and the best results follow early operation.

SUMMARY

Arterial injuries in association with blunt, non-penetrating trauma are recognized with increasing frequency. While the arteries of the extremities are most commonly involved, visceral arteries are occasionally affected. Partial disruption of the arterial wall with thrombosis is the most frequent injury. Arteriography has assumed increasing importance in defining the site and extent of peripheral arterial injuries. Failure to diagnose such injuries early can lead to irreversible ischemic changes or death. The most effective treatment for such injuries is early exploration and re-establishment of arterial continuity.

REFERENCES

1. Couves, C. M.; Lumpkin, M.B.; and Howard, J.M.: Arterial Injuries Due to Blunt (Non-penetrating) Trauma: Experiences with Fifteen Patients. Canadian J. Surg., **1:** 197–200, 1958.
2. DeBakey, M.E., and Simeone, F.A.: Battle Injuries of the Arteries in World War II. An Analysis of 2,471 Cases. Ann. Surg., **123:** 534–579, 1946.
3. Elliott, J.A.: Acute Arterial Occlusion: An Unusual Case. Surgery, **39:** 825–826, 1956.
4. Hughes, C.W.: Arterial Repair During the Korean War. Ann. Surg., **147:** 555–561, 1958.
5. Kinmonth, J.B.; Simeone, F.A.; and Perlow, V.: Factors Affecting the Diameter of Large Arteries with Particular Reference to Traumatic Spasm. Surgery, **26:** 452–471, 1949.
6. Lumpkin, M.B.; Logan, W.D.; Couves, C.M.; and Howard, J.M.: Arteriography as an Aid in the Diagnosis and Localization of Acute Arterial Injuries. Ann. Surg., **147:** 353–358, 1958.
7. Moore, T.C.: Acute Arterial Obstruction Due to Traumatic Circumferential Intimal Fracture. Ann. Surg., **148:**111–114, 1958.
8. Morris, G.C., Jr.; Creech, Oscar, Jr.; and DeBakey, M.E.: Acute Arterial Injuries in Civilian Practice. Am. J. Surg. **93:** 565–572, 1957.

Quadriplegia Due to Guinea-Worm Abscess

BY JAMES R. DONALDSON, M.D., AND THOMAS A. ANGELO, M.B., B.S.,
MIRAJ, BOMBAY STATE, INDIA

From the Wanless Hospital, Miraj

In the localities where guinea-worm infestations are common, it is recognized that deep abscesses may form in various parts of the body and that joints may be affected in addition to the more characteristic superficial sore that is found on the lower extremity. Furthermore, calcified guinea worms may be visualized in various parts of the body as incidental findings when roentgenograms are made for other reasons. To our knowledge, this is the only reported case of a patient having quadriplegia from a guinea-worm abscess within the spinal canal, with recovery after a laminectomy and removal of the guinea worm. Although we knew that the patient suffered from guinea-worm infestation, it did not occur to us that this was the cause of his quadriplegia until after exploration was done and the guinea worm was found.

CASE REPORT

L.S.A., a man thirty-five years old, was admitted to the hospital on September 29, 1958. About four months before admission, pain and stiffness had developed in the neck, gradually worsening. Three weeks before admission, weakness of the right upper extremity developed. Twelve days before admission paresis of both lower extremities developed, and the patient was unable to walk. Four days before admission the left arm became weak. The patient had lancinating pains throughout his entire body and had difficulty with sphincter control; he had an ulcer on his left leg just above the ankle that was due to a guinea worm.

Physical examination revealed a well developed and well nourished man who was unable to walk and who had complete loss of control of the right upper extremity and almost complete loss of control of the left upper extremity and paralysis of both lower limbs. The reflexes were exaggerated in all four extremities. There was tenderness in the posterior aspect of the neck that was poorly localized; motion of the neck in all planes was restricted. The pupils were equal and reacted to light. The ulcer on the left leg was about one-quarter of an inch in diameter, and there was a minimum amount of inflammatory reaction at the border.

The cerebrospinal fluid was examined, and the cell count, chloride, and sugar were within normal limits; the protein was slightly elevated. The Queckenstedt test was positive, showing complete obstruction to the flow of spinal fluid. Examinations of the blood and urine were within normal limits. Stool examination revealed ascaris and ancylostoma infestation.

On October 20, a myelogram was performed through a cisternal puncture; it was not possible to make the contrast medium enter the spinal subarachnoid space.

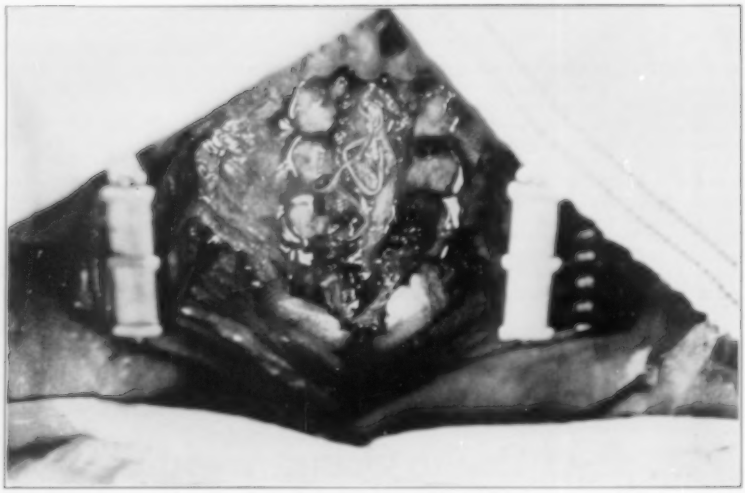


FIG. 1

Fragment of guinea worm lying on the dura at the level of the first, second, and third cervical vertebrae.

On October 29 the upper cervical canal was explored. Laminectomy was performed from the fourth cervical level to the occiput. At the fourth cervical level there was no pulsation of the cord. The wall of the abscess started at the third cervical level and extended to the foramen magnum. Small pockets of pus were encountered as the granulation tissue was gently dissected from the dura. The pus was thick, pale yellow, and odorless. In one pocket of pus, a portion of a guinea worm was found and was slowly extracted. The worm broke in two places, but further dissection allowed the end to be recovered, and, in all, fifty-one centimeters of worm were removed. Pulsations returned to the cord after the thick wall of the abscess had been removed. The wound was closed with cotton suture.

The postoperative course was uneventful. On the twenty-fifth postoperative day, the patient stated that strength was returning to all four extremities. On the thirtieth postoperative day he could slightly flex both hips and both elbows and insisted on being discharged from the hospital.

Fourteen months later the patient returned for follow-up. Recovery was complete, and the patient had started work as a watchman eight months after discharge.

Bilateral Osteosarcoma in the Phalanges of the Hand

A Solitary Case Report*

BY BENJAMIN W. DROMPP, M.D., DETROIT, MICHIGAN

From the Departments of Orthopedic Surgery, Wayne State University College of Medicine, and the Detroit Receiving Hospital, Detroit

A solitary case presentation is justified only if the case is exceedingly rare or if there exists a set of unusual circumstances in it. The case to be presented in this paper fulfills all of the just-mentioned criteria, because osteosarcoma is quite rare in the phalanges of the hand. Osteitis deformans was suspected as being the underlying bone disease in the phalangeal tumors in this case; this combination has never before been reported. The presence of bilateral osteosarcoma of the phalanges of the hand and the reasonable suspicion that this represents malignant degeneration and osteitis deformans are the most unusual of circumstances. Since osteitis deformans was first described by Sir James Paget in 1877, a number of reviews [1,4,7,9,14,15] concerning the incidence of osteitis deformans, the incidence of sarcomatous degeneration in osteitis deformans, and the incidence of the occurrence of osteitis deformans in the upper extremity have been published. It should be noted that there seem to be many inaccuracies in reporting these aspects of osteitis deformans.

FIG. 1

FIG. 2

Fig. 1: Photograph of the right hand, showing the swollen long finger, 1954.
Fig. 2: Roentgenogram of the right long finger, showing changes in the proximal phalanx, 1954.

* Revision of the paper read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 22, 1960.

FIG. 3

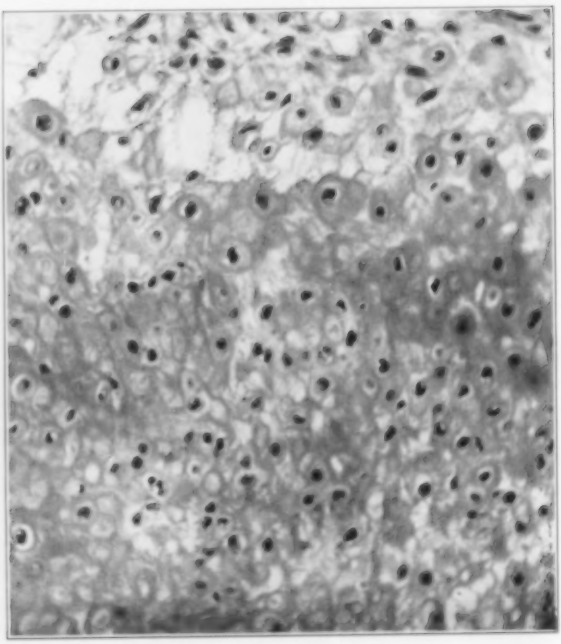


FIG. 4

Fig. 3: Roentgenogram of the right tibia, showing anterior bowing and bone structure suggestive of osteitis deformans, 1954.

Fig. 4: Photomicrograph of area of the resected specimen from the right long finger, showing the predominance of chondroid elements, allowing chondrosarcoma to be considered as the diagnosis, 1954.

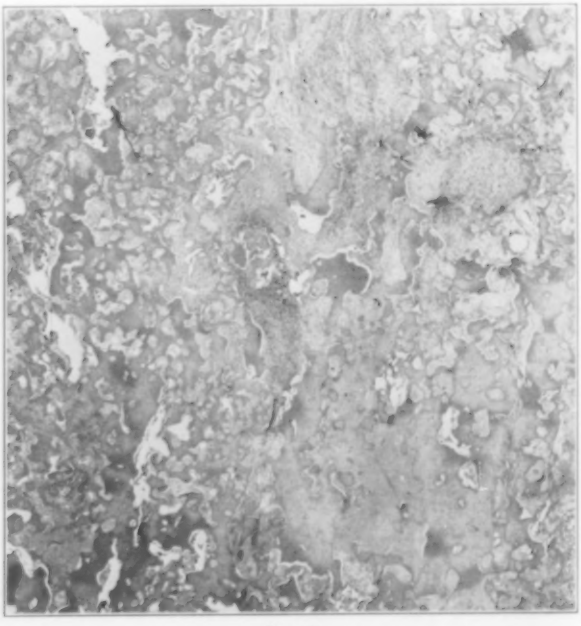


FIG. 5

Photomicrograph of the lesion suggestive of osteitis deformans, 1954 (× 9).

There has been more reliable and accurate reporting of bone sarcoma of the digits of the hand. Carroll, reporting on osteogenic sarcoma of the hand in 1957, reviewed the literature and found a total of four cases of osteogenic sarcoma involving the phalanges of the hand. One additional case in the literature has been reported by Moseley and Bass, with the phalanx of the hand involved in multiple sclerosing osteogenic sarcoma in a five-year-old girl. Thus, the case reported in this paper, although previously reported with a different diagnosis, represents the sixth and seventh case involving the phalanx of the hand in which osteogenic sarcoma has been proved and reported in the literature to date.

CASE REPORT

C.L., a Negro man, seventy-eight years old, was first seen at the Detroit Receiving Hospital in October 1954. He complained of a tender swelling in the right long finger of three weeks' duration (Fig. 1). At first it was believed that this represented an acute exacerbation of chronic osteomyelitis in this finger, and the patient was admitted to the hospital for incision and drainage.

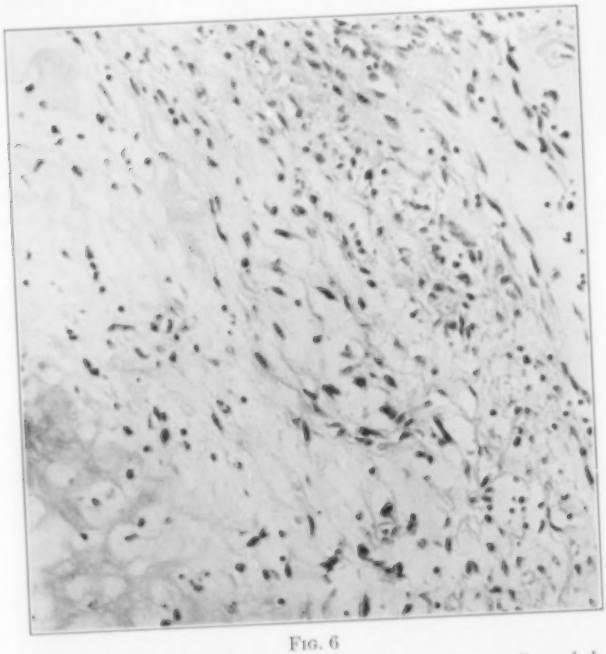


FIG. 6

Photomicrograph of the lesion, showing the area of osteosarcoma, as well as of chondrosarcoma, 1954 (× 220).

The patient said that he had an injury to this finger more than twenty years previously, but he insisted that the increased swelling and tenderness had been present only for the past two or three weeks. The only other significant detail in the past history was that he had undergone transurethral resection three years previously for benign prostatic hypertrophy.

Examination of this patient revealed no obvious abnormalities, with the exception of hypertension and the physical findings in his right hand. A tender, fusiform swelling of the proximal phalanx of the long finger, associated with considerable limitation of motion, was described. The left hand also was examined, and only one observer noted any abnormality in the fingers of this; this was an inconclusive finding, however, and this examiner failed to note in the clinical examination which finger he thought had an abnormality.

The roentgenograms were reviewed by the Radiology Department, and it was believed that the roentgenographic picture was that of osteosarcoma superimposed on osteitis deformans (Fig. 2). A bone survey was obtained. The chest was reported as normal and without evidence of metastasis.

FIG. 7

FIG. 8

Fig. 7: Photograph of both hands, showing the swollen left index finger, 1957.
Fig. 8: Roentgenogram of the left index finger, showing changes in the proximal phalanx, 1957.

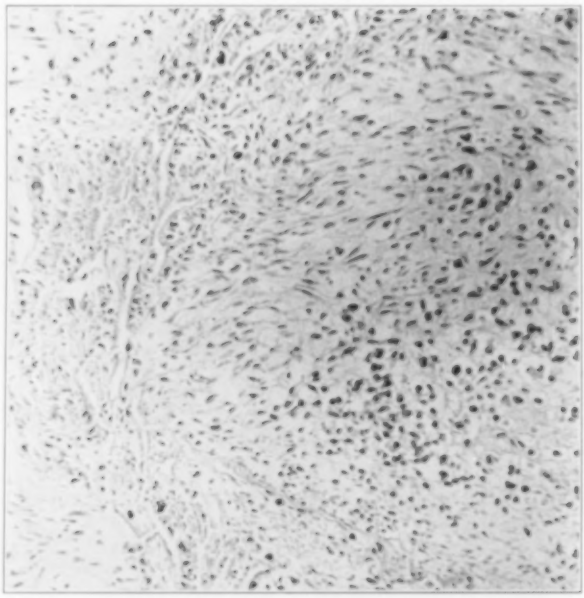


FIG. 9

Photomicrograph of the left index finger, showing the area of osteosarcoma, 1957 (× 220).

The skull, pelvis, and thoracic and cervical spine were reported as normal. The body of the second lumbar vertebra and the right tibia (Fig. 3) were reported as having minor but characteristic changes of early osteitis deformans. Roentgenograms were not made of the left hand.

Laboratory work was done on admission: the hemoglobin level, blood urea nitrogen, white-blood-cell count, and serum calcium were all within normal limits. The serological test for syphilis

was negative. The alkaline phosphatase was reported as being 3.6 Bodansky units, and the acid phosphatase was reported as 0 Bodansky units.

The patient's lesion was biopsied in October 1954, and the Pathology Department reported the biopsy as being consistent with chondrosarcoma (Fig. 4). A ray resection of the long finger and metacarpal was performed in October 1954, after the biopsy report. Once again, the Pathology Department reported that the specimen was consistent with chondrosarcoma superimposed on hypertrophied bone that was not histologically typical of osteitis deformans. [Subsequent review of the histological sections (Fig. 5) caused this opinion to be revised, and the lesion was reclassified as osteosarcoma (Fig. 6).]

Upon recovery from his surgery, the patient was followed in the Out-Patient Department. Frequent chest roentgenograms were always reported as negative for metastasis. Repeated examinations of the hand failed to disclose any local recurrence.

In April 1957 the patient was readmitted to Receiving Hospital on the Orthopedic Service because of a painless swelling in his left index finger. He had first noticed this swelling four weeks previously and stated that the swelling had gradually increased.

Physical examination revealed as the only new finding a fusiform swelling of his left index finger (Fig. 7), as well as a healed surgical scar on the right hand; the physical findings were otherwise the same as those that existed at his 1954 admission.

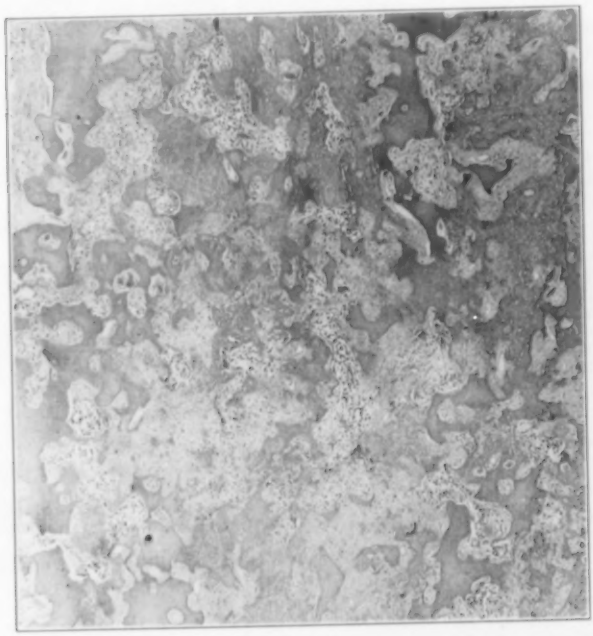


FIG. 10

Photomicrograph of the left index finger, showing an area suggestive of osteitis deformans and an area of osteosarcoma, 1957 (× 21).

The laboratory findings were unchanged from those at his previous admission—the alkaline phosphatase was 4 Bodansky units, and so forth. The roentgenogram of the chest was still negative, as was the bone survey. The roentgenograms of the left index finger were considered to be representative of osteosarcoma (Fig. 8). After review of the roentgenograms and past history, primary ray resection was recommended and was performed on April 12, 1957. The pathological report was that this specimen was osteosarcoma (Fig. 9) superimposed on osteitis deformans (Fig. 10).

The patient recovered from his surgery without difficulty and was discharged to the clinic for follow-up care. He was followed in the Out-Patient Clinic after that and was last seen in July 1960. No evidence of recurrence was shown by roentgenographic and clinical examination. At this time a biopsy was performed on the middle third of the right tibia; the specimen was reported as showing no histological characteristics of osteitis deformans. An alkaline-phosphatase determination was once again within normal range—4.4 Bodansky units.

DISCUSSION

In discussion of this solitary case report, one should note that originally the lesion of the right long finger was interpreted as representing chondrosarcoma because of the predominance of cartilage cells in the histological sections. On the basis of this opinion, Posch, in a paper in 1956 concerning tumors of the hand, included this case as representing chondrosarcoma. However, when the histological sections of the left index finger revealed typical osteosarcoma, the original diagnosis of chondrosarcoma of the right long finger was in doubt. The entire case was then reviewed by a number of pathologists [2,5,8,10,11], all of whom were unanimous in the belief that bilateral osteosarcoma was the proper diagnosis in this case. There was much less concurrence in deciding on the underlying bone pathology in this case. The failure to demonstrate a histological picture of osteitis deformans in the right tibia and the persistence of normal alkaline-phosphatase determinations throughout the period of study of this patient suggest that osteitis deformans is not the underlying bone disease in this case.

In summary, a solitary case of bilateral osteosarcoma of the phalanges of the hand has been presented because of the rarity of this lesion. It is our belief that the osteosarcoma in this case does not represent malignant degeneration of osteitis deformans.

REFERENCES

1. Bird, C. E.: Sarcoma Complicating Paget's Disease of Bone. Report of Nine Cases, Five with Pathologic Verification. Arch. Surg., **14:** 1187–1208, 1927.
2. Brines, O. A.: Personal communication.
3. Carroll, R. E.: Osteogenic Sarcoma in the Hand. J. Bone and Joint Surg., **39-A:** 325–331, Apr. 1957.
4. Coley, B. L., and Sharp, G. S.: Paget's Disease. Predisposing Factor to Osteogenic Sarcoma. Arch. Surg., **23:** 918–936, 1931.
5. Dahlin, D. C.: Personal communication.
6. Goldenberg, R. S.: Personal communication.
7. Gruner, O. C.; Scrimger, F. A. C.; and Foster, L. S.: A Clinical and Histological Study of a Case of Paget's Disease of the Bones with Multiple Sarcoma Formation. Arch. Int. Med., **9:** 641–656, 1912.
8. Hatcher, C. H.: Personal communication.
9. Jaffe, H. L.: Paget's Disease of Bone. Arch. Pathol., **15:** 83–131, 1933.
10. Johnson, L. C.: Personal communication.
11. Lichtenstein, Louis: Personal communication.
12. Moseley, J. E., and Bass, M. H.: Sclerosing Osteogenic Sarcomatosis. Radiologic Entity. Radiology, **66:** 41–45, 1956.
13. Posch, J. L.: Tumors of the Hand. J. Bone and Joint Surg., **38-A:** 517–540; 562, June 1956.
14. Sear, H. R.: Osteogenic Sarcoma as a Complication of Osteitis Deformans. British J. Radiol., **22:** 580–587, 1949.
15. Summey, T. J., and Pressly, C. L.: Sarcoma Complicating Paget's Disease of Bone. Ann. Surg., **123:** 135–153, 1946.

An Adjustable Lower-Extremity Brace

BY THOMAS L. DELORME, M.D., LAIRD JOHNSON, B.S., PETER LUCHINI, B.S., WILLIAM BORA, M.D., AND JAMES MORRISSEY, M.D., BOSTON, MASSACHUSETTS

From the Department of Mechanical Engineering, Massachusetts Institute of Technology, and the Massachusetts General Hospital Rehabilitation Service and Brace Shop, Boston

In the investigation and management of gait problems in certain neuromuscular and musculoskeletal disorders, the need for an adjustable leg brace frequently arises. A search of the literature on appliances failed to reveal any article on an effective adjustable device. It is the purpose of this article to describe the design and use of such an apparatus.

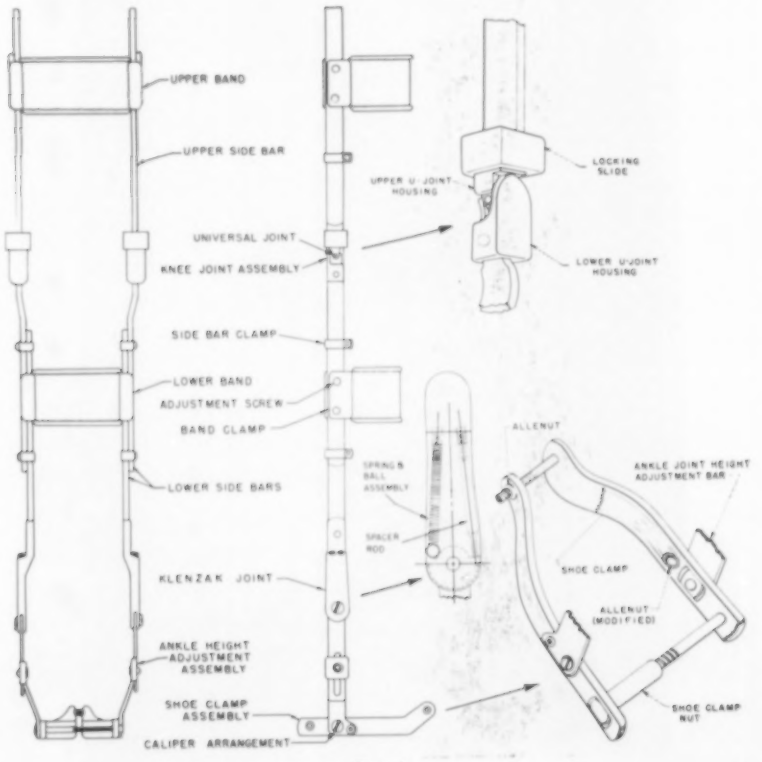


FIG. 1

From left to right are shown sketches of the front and side of the brace. Detailed sketches of the knee, ankle, and foot pieces are shown on the far right.

DESCRIPTION OF THE BRACE

General Description

The brace that was developed during this investigation consists of calf and thigh bands, two adjustable side bars, or uprights, joints at the knee and ankle, and a shoe clamp by which the brace is attached to the heel of the shoe. Each

component of the brace is independently adjustable, thereby making the appliance adaptable to either the right or left lower extremity and to patients of all builds, except for those who are exceptionally tall, short, or fat. For children, a special brace is used, since the components of the adult-size brace are too large. When assembled as a long brace, the apparatus weighs six pounds; when used as a short brace it weighs three pounds.

Side Bars

The length of the duraluminum side bars can be adjusted at three levels: between the shoe-clamp assembly and the ankle joint, between the ankle and knee, and between the knee and thigh band. The adjustments are accomplished by moving the thigh band up and down on the upper side bars and by moving the adjustable sliding bars below the knee and ankle (Fig. 1).

FIG. 2

The brace is shown accommodating the valgus deformity of the knee.

Ankle Joint

The ankle joint is a double-action Klenzak joint. The function of this joint is adjusted by the insertion of springs and spacer rods in appropriate combinations (Fig. 1) to provide dorsiflexion or plantar-flexion assist, with or without dorsiflexion or plantar-flexion stops. The stops can be adjusted for any desired position of the foot. By removal of both the springs and spacer rods, a free joint can be

provided. By inserting two spacer rods, the joint can be made rigid, but it can be set in any desired position of plantar flexion or dorsiflexion by means of the set screws. In a like manner, if a caliper joint at the heel is desired, the joint at the level of the ankle can be eliminated by the insertion of two spacer rods, and the caliper joint can be provided by the removal of the caliper-adjustment screws in the shoe clamp (Fig. 1).

The distance between the axis of rotation of the ankle joint and the heel can be altered, as necessary, by the adjustment slide. Either side may be changed separately to allow for varus or valgus deformity at the ankle.

Knee Joint

At the knee there is a universal joint that permits adjustment for varus or valgus deformity, as well as for flexion and extension. Lateral stability, once

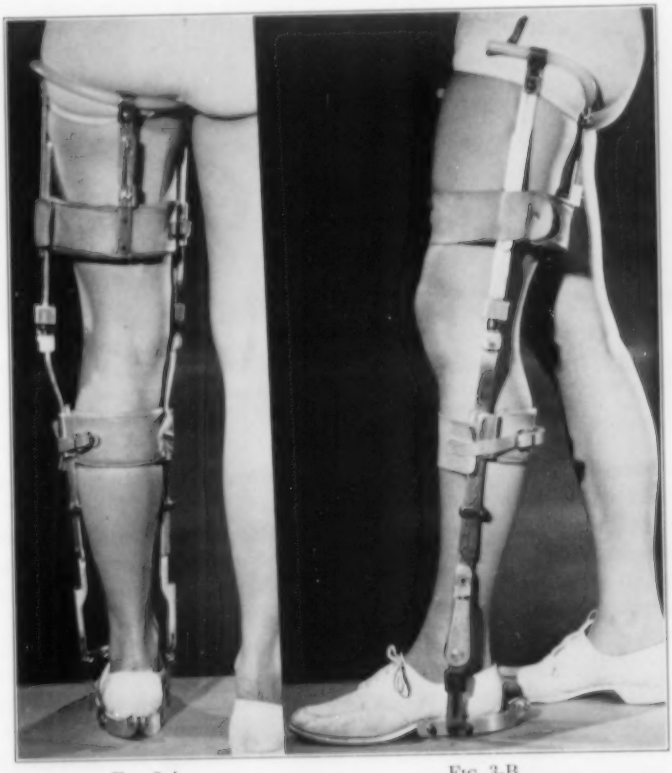


FIG. 3-A FIG. 3-B

FIG. 3-A: Rear view showing use as an ischial weight-bearing brace.
Fig. 3-B: Side view of ischial weight-bearing brace.

the proper amount of varus or valgus position has been selected, is maintained by the thigh and calf bands, which clamp rigidly to the side bars, as well as by the shoe clamp (Fig. 2). There is a drop lock at the knee joint that enables the patient to walk with either a free or fixed knee joint.

Bands

The thigh and calf bands are semicircular bands of duraluminum with L-clamps at each end. As already indicated, when these bands are clamped in place on

FIG. 4-A

FIG. 4-B

FIG. 4-C

FIG. 4-D

Figs. 4-A and 4-C: Caliper-type brace.

Figs. 4-B and 4-D: Free-ankle arrangement. (By replacement of the spacer rods in the Klenzak joint and of the Allen nut in the shoe clamp, a rigid ankle in any desired position of dorsal or plantar flexion is obtainable.)

the side bars, they make the brace rigid and prevent lateral movement in the universal joint at the knee.

The thigh and calf bands are of various sizes to accommodate limbs of different dimensions. The distances between the ends of the bands (the diameters of their circles) range from three and one-half to eight inches in three-quarter-inch increments. All the bands are padded and leather-covered.

Ischial Support

The ischial support consists of a polyethylene rod one-half inch in diameter, to which three uprights are attached by sliding couplings (Fig. 3-A). These uprights clamp to the side bars of the brace on each side and to the thigh band behind. The height of each upright can be adjusted separately. The polyethylene rod is sufficiently rigid to provide adequate support, yet flexible enough to accommodate thighs of different sizes.

Shoe Clamp

The shoe clamp consists of two side members curved to conform to the shape of the heel. They are connected by two Allen bolts and nuts—one behind the heel, and the other in front, beneath the shank of the shoe. Serrations on the inner side of the two curved members enable the clamp to obtain a firm grip on the heel of the shoe when the Allen bolts are tightened.

The lower ends of the side bars of the brace are L-shaped and attached to the

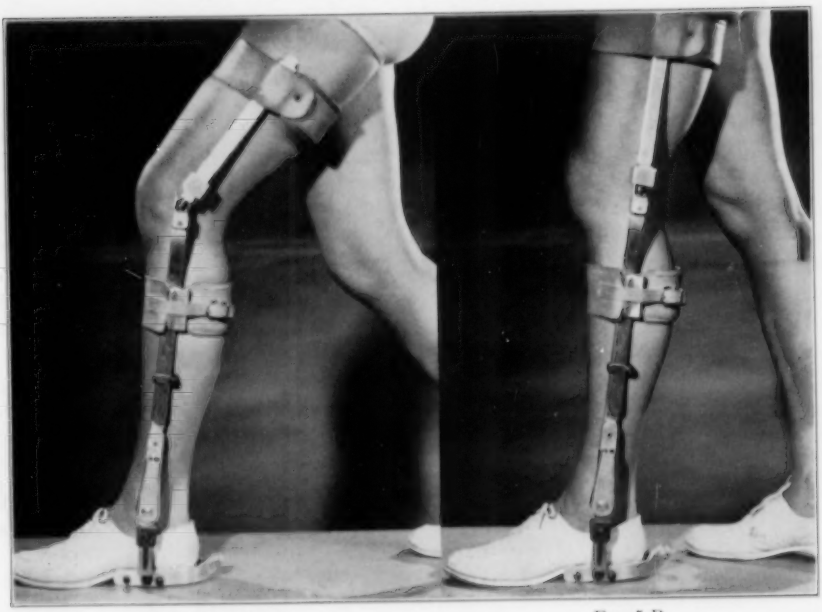


FIG. 5-A FIG. 5-B

Fig. 5-A: Long brace with knee free.
Fig. 5-B: Long brace with knee locked.

shoe clamp by a pivot and caliper-adjustment screw (Fig. 1). With the adjustment screws in place, the side bars are fixed at right angles to the shoe clamp (Fig. 1).

Mechanical Failure

This brace has been in use for more than a year at the time of writing. During this time there was only one mechanical failure; this occurred when the duraluminum tongue of the knee lock (Fig. 1) broke. This was replaced by a stainless-steel tongue, and no further trouble has been encountered.

APPLICATIONS OF THE BRACE

There are many situations in which such a quickly adjustable brace has obvious advantages.

In the early stages of some neurological diseases, such as multiple sclerosis, poliomyelitis, and cerebrovascular accidents, muscle function may change rapidly, necessitating frequent adjustment in the supportive apparatus. The adjustable brace is admirably suited for these situations.

In long-standing complex neuromuscular disorders with firmly established abnormal gait patterns, it is, at times, difficult to determine the most satisfactory type of brace for a particular patient. Often, a brace that is theoretically correct is unsatisfactory, and the best device for a given patient can be determined only after trial and error, using several braces. The adjustable brace provides an economical and rapid means of determining the most suitable apparatus under these circumstances.

During convalescence from certain reconstructive procedures, there are times when the short-term use of a brace for protection is desirable but often not justified because of the high cost of a conventional brace. The adjustable brace fills this temporary need.

Rehabilitation is not infrequently delayed while a permanent apparatus is being fabricated. Temporary use of the adjustable brace during this time allows rehabilitation to continue uninterruptedly.

At times there is need to demonstrate to a patient how a contemplated surgical procedure will affect his gait and other activities or how a new type of apparatus will function. At other times, there may be doubt as to whether a patient will consent to wear a brace after it has been completed and adjusted. In these situations the patient can be fitted with the adjustable brace and, almost immediately, he can experience its effect and learn how the permanent brace will feel and appear in actual use.

Similar diseases and disabilities do not necessarily call for the same type of brace. Much can be gained by giving the patient some say in the selection of a brace that is finally prescribed. A temporary brace used in this way can substantially reduce the number and extent of the alterations that are required before a permanent brace is finally acceptable to the patient.

Another desirable feature of this adjustable brace is its value as a training aid. By trial and error, the orthopaedic resident soon learns the mechanics of bracing. With this device, errors in prescription do not entail expense chargeable to the patient's account. The brace most effective in particular circumstances soon becomes apparent to the resident who adjusts this brace himself.

Similarly, while treating a patient with this brace, the physical therapist has the opportunity to determine the function of various types of braces in different disabilities. In addition, the therapist can make immediate adjustments to correlate with the patient's performance and can modify the brace as often as necessary to fit the patient's progress.

DISADVANTAGES

The brace is not completely adjustable. It cannot be firmly clamped to all types of shoe heels, nor can it be adjusted to fit some extremities.

Each adjustment requires the loosening and tightening of several set screws. If a number of different types of braces are to be tested when a brace is to be prescribed, considerable time must be spent in making adjustments. Also, major adjustments are too time-consuming to make it feasible to use one brace concurrently for several patients.

A certain amount of ingenuity is required to use and adjust the brace. It has many parts that must be kept in working order and not lost.

The patient must be warned that the serrations on the shoe clamp will cause some damage to the heel of the shoe.

CONCLUSIONS

An adjustable brace of the type described is of practical value in the evaluation and treatment of gait disturbances. Unquestionably, the adaptability of the brace can be increased by change in design. The importance of the present brace is that it has demonstrated that an adjustable brace is technically feasible, practical, and of clinical value.

Operative Treatment for Recurrent Dislocation of the Temporomandibular Joint

BY CAROLL M. SILVER, M.D., AND STANLEY D. SIMON, M.D.,
PROVIDENCE, RHODE ISLAND

Recurrent dislocation of the jaw is not a common disability, but is most distressing when it does occur. The individual is afraid to open the mouth widely while eating, and must be on guard when laughing or yawning. Each recurrence produces further stretching and laxity of the temporomandibular-joint capsule, thereby facilitating the next painful dislocation. With Savastano, we reported a study of forty-four patients operated on for injuries of the meniscus of the temporomandibular joint in 1956 [14]. In a majority of cases after operation, it was noted that a slight deviation of the mandible to the side operated on occurred when the patient opened the mouth widely.

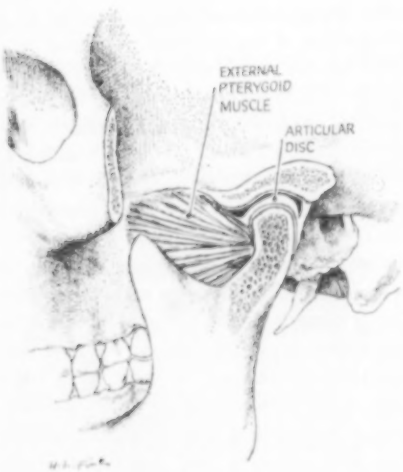


FIG. 1

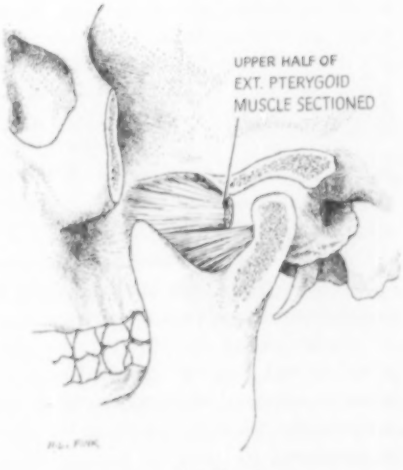


FIG. 2

Fig. 1: The external pterygoid muscle exerts forward pull on the mandibular condyle and meniscus (articular disc) as the mouth is opened.

Fig. 2: The meniscus has been excised, and the upper half of the external pterygoid muscle has been sectioned, weakening the forward pull on the condyle.

The meniscus of the temporomandibular joint is a dense fibrous disc that glides forward under the temporal bone concurrently with the hingelike action of the mandibular condyle beneath it during normal opening of the mouth. The forward movement of the meniscus and condyle is activated by the contraction of the external pterygoid muscle, which inserts partly into the anterior margin of the meniscus and partly into the condyle and neck of the mandible (Fig. 1).

It occurred to us that the slight deviation of the mandible to the side of the meniscectomy was probably related to partial section of the insertion of the external pterygoid muscle during removal of the anterior attachment of the meniscus. The resultant weakening of the forward pull of this muscle on the mandibular condyle was thought to be the cause of the diminished forward excur-

sion of the mandibular condyle on the involved side and the observed deviation of the mandible to that side. From clinical observations, we are convinced that it is the partial section of the external pterygoid muscle that causes the deviation of the mandible, since this is noted on the first day after operation, when scarring and adhesions could not possibly account for this deviation. Furthermore, at operation, immediately after removal of the meniscus, the mandibular condyle (and mandible) can be pulled forward freely in the mid-line so that the postoperative deviation of the mandible cannot be ascribed to limitation of motion of this condyle, resulting from the meniscectomy proper.

The external pterygoid muscle, as observed during many operations on the temporomandibular joint, is a bulky, powerful muscle. Section of one-half of it could certainly account for the deviation of the mandible noted after operation. During routine meniscectomy, the amount of this muscle sectioned varies according to the extent to which the muscle inserts into the meniscus and related capsule. Differences in the amount of muscle sectioned could well explain the variations in the amount of deviation observed after simple meniscectomy.

A review of these findings led to the conclusion that deliberate section of part of the insertion of the external pterygoid muscle into the mandibular condyle and neck would be a logical and technically simple procedure for the treatment of recurrent dislocation of the jaw. Since the temporomandibular meniscus is, in effect, an intra-articular extension of the insertion of the external pterygoid muscle, it seemed possible that section of the attachment of this muscle to the meniscus might convert it into a loose body in the joint (Fig. 2). For this reason, meniscectomy was thought to be indicated after section of the external pterygoid.

This report is a case study of recurrent dislocation of the jaw, treated by partial section of the insertion of the external pterygoid muscle and by temporomandibular meniscectomy. The patient has been followed for five years since operation, with periodic roentgenograms of the temporomandibular joints.

We have not included a second case, a man with an excellent result whom we have followed for only one year since operation; in this instance a condylectomy was also performed because of definite arthritic changes in the mandibular condyle.

In reviewing the literature for the preparation of this report, we were surprised to find that our idea had been anticipated by Boman, in Sweden, in 1949, based on identical observations of deviation of the mandible after meniscectomy. Accordingly, we make no claim for originality, but believe that this study should be presented to bring to general attention this effective and relatively simple operation for recurrent dislocation of the temporomandibular joint.

GENERAL DATA

Sex and Age

Review of the literature indicates that recurrent dislocation is most frequent in young women; it is often bilateral.

Causes of Recurrent Dislocation

Trauma may cause dislocation. This often occurs in epileptics.

Degenerative changes in the temporomandibular joint may cause recurrent dislocation. With constant wear and tear, the height of the articular tubercle is worn down, and the depth of the temporal fossa is reduced. As a result, relatively little force is required to produce dislocation in the presence of these changes.

Types of Recurrent Dislocation

Two types [4] of recurrent dislocation have been distinguished:

1. Meniscotemporal dislocation, occurring in the upper joint cavity, when the meniscus and mandibular condyle move forward in unison and dislocate in front of the articular tubercle;

2. Meniscocondylar dislocation, occurring in the lower joint cavity, when the condyle alone is dislocated and displaced anterior to the meniscus. Actually, the distinction between these two types of dislocation is of more theoretical than practical concern.

TREATMENT

Prophylactic Treatment

After the first or second dislocation of the jaw, prolonged rest of the temporomandibular joint for at least a month is important. This is done most simply by dental wiring with rubber bands to limit the range of opening of the mouth. If recurrent dislocation is well established, however, the method is of no actual value.

Conservative Treatment

Local injection of fibrosing solutions [6,7,11] to tighten the joint capsule has been used, including tincture of iodine, alcohol, and sodium psylliate. Since results are uncertain, and the risks of facial-nerve paralysis and traumatic arthritis are very real [12], this so-called conservative treatment is advised against by several authors.

Operative Treatment

Operation is the treatment of choice in well established recurrent dislocation of the jaw. Many types of operation have been devised and reported on—a fact that indicates that probably none has been completely satisfactory in all hands. These procedures fall into several categories: (1) production of some form of anterior block; (2) anchorage of the mandibular condyle; (3) removal of mechanical factors that can interfere with free condylar movements; and (4) reduction of muscle power activating forward movement of the mandibular condyle.

1. Production of Some Form of Anterior Block

Three procedures have been used: (1) an anterior bone block fashioned from a bone peg [9] taken from the zygoma and inserted just anterior to the joint (Mayer); (2) osteotomy of the tubercle of the temporal bone with downward tilting of the anterior portion of the tubercle to increase the depth of the fossa [8]; and (3) Konjetzny's operation [7], in which the meniscus is detached posteriorly and anteriorly and then folded forward so that its posterior edge can be attached to the pterygoid and masseter muscles. These three procedures are technically difficult, and the bone-block procedures require prolonged immobilization of the jaw after operation.

2. Anchorage of Mandibular Condyle

Three procedures have been described: (1) A strip of dermis from behind the ear is passed subcutaneously from above and behind the ear to the capsule of the temporomandibular joint. This dermal graft is attached under appropriate tension to the periosteum of the temporal bone and to the joint capsule as a sling. A capsulorrhaphy is also performed (Rehn's procedure) [4]; (2) a loop of temporal fascia is used to form a similar supporting sling (Nieden's method) [4]; and (3) a strip of fascia lata, passed through holes in the mandibular condyle and base of the zygoma, is used to suspend the condyle and limit its forward movement, and meniscectomy is also performed (Gordon's method) [5]. All these procedures are technically complicated, and each requires several weeks of immobilization of the jaw.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Photograph made in 1958, almost three years after operation.
Fig. 3-B: Photograph made in 1958, showing that the mandible deviates slightly to the operated (left) side when the mouth is opened wide.

3. Removal of Interfering Mechanical Factors

There are three methods to remove mechanical factors that interfere with free condylar movements: (1) extirpation of the meniscus, which was first performed by Ashhurst for recurrent dislocation of the jaw [1]; (2) resection of the mandibular condyle (Riedel's method) [2]; and (3) removal of the entire temporal-bone tubercle, so that the mandibular condyle cannot catch anteriorly [10]. All three procedures are mechanically sound and not technically difficult. The first-mentioned method could be made more efficient by partial section of the insertion of the external pterygoid muscle, as will be described later.

4. Reduction of Muscle Power

Reduction of the muscle power activating the forward movement of the mandibular condyle may be effected by the detachment of one-half of the insertion of the external pterygoid muscle and meniscectomy to eliminate a potential mechanical blocking factor (Boman's method). This procedure is not technically difficult, involves soft-tissue surgery only, and allows immediate use of the jaw. In our opinion, based on our previous work with the temporomandibular joint, this procedure is excellent for recurrent dislocation of the jaw.

CASE REPORT

R.T., a white man, twenty-three years old, was seen in September 1955, with a history of recurrent dislocation of the jaw of two years' duration. The initial episode had occurred after a hearty yawn; general anesthesia was required for reduction. Thereafter, recurrent dislocations of the jaw had occurred with increasing frequency. They could usually be reduced by the patient, but during the past few months several dislocations occurred each week, and some of these were reduced with difficulty even when general anesthesia was used. The patient stated that, recently, the condition had become so marked that the jaw dislocated even if he simply talked loudly or ate a sandwich. The pain at the time of each dislocation was consistently referred to the left temporomandibular joint. Roentgenograms of the temporomandibular joints showed nothing remarkable.

The patient was admitted to the Miriam Hospital, in Providence, on September 15, 1955. Operation on the left temporomandibular joint was performed on September 16, 1955, with removal of the meniscus and section of the upper half of the external pterygoid muscle. When the temporomandibular joint was first exposed, the jaw could easily be dislocated under direct vision, and the mandibular condyle was found to lock anterior to the meniscus, which constituted a mechanical block.

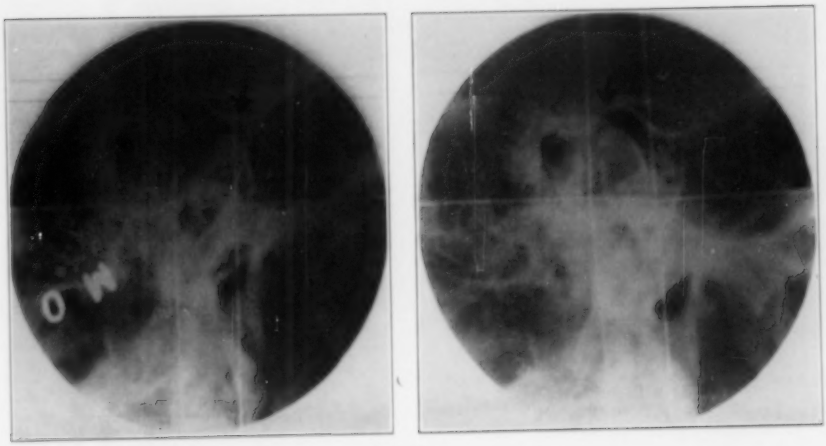


FIG. 3-C

Figs. 3-C and 3-D: Roentgenograms made on April 20, 1960, four and one-half years after operation.

Fig. 3-C: Note the fair range of forward motion of the mandibular condyle in the mouth-open (*MO*) position.

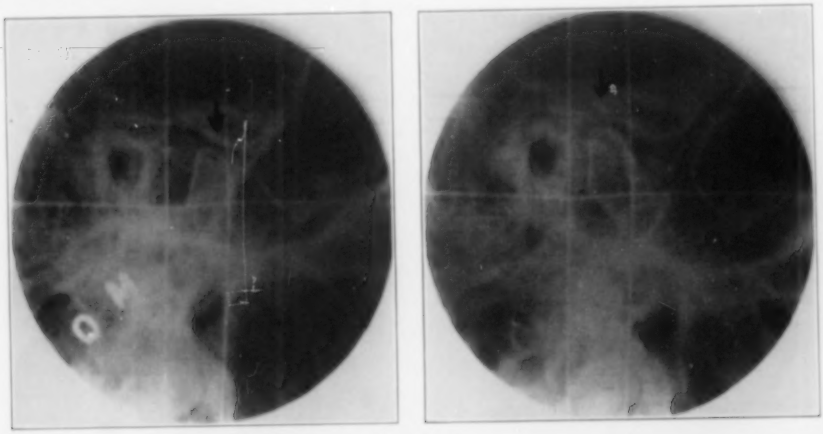


FIG. 3-D

There is appreciable restriction of the forward motion of the mandibular condyle in the mouth-open (*MO*) position on the side operated on. Note the slight flattening of the mandibular condyle.

The patient's immediate postoperative course was uneventful. No paresis of the forehead muscles occurred, and he ate soft food on the day after surgery. All sutures were removed from the healed wound on the third postoperative day, and the patient was discharged at that time (September 19, 1955).

Three months after operation, the patient stated that he had no trouble with his jaw and was able to eat everything. When he opened his mouth completely there was a distance of one and one-quarter inches between the tips of the incisor teeth (almost normal range), with a slight shift of the mandible to the left.

Roentgenograms made at periodic intervals up to the time of writing have shown a definite partial restriction of forward excursion of the left mandibular condyle in the open-mouth view, as compared with the right, indicating that the desired effect of the operative procedure has been maintained. The most recent roentgenograms in April 1960 (Figs. 3-C and 3-D), four and one-half years after operation, demonstrate this finding clearly. It is to be noted that there has been a slight flattening of the top of the mandibular condyle on the left, in response to the altered mechanical stresses. The patient's clinical appearance almost three years after operation is shown in Figures 3-A and 3-B.

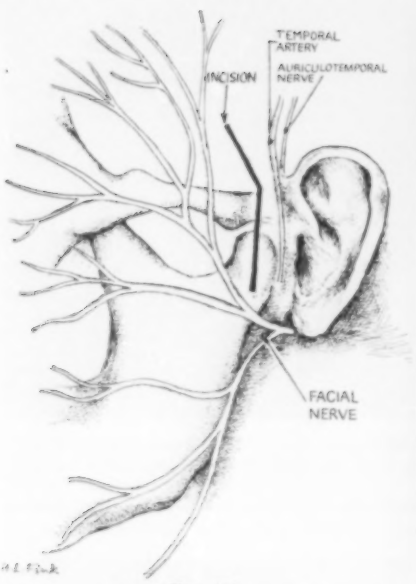


FIG. 4-A

FIG. 4-B

Fig. 4-A: Diagram of the Thoma incision and its relationship to the important neurovascular structures. (Reproduced from Oral Surgery, vol. 2, p. 902. By K.H. Thoma. St. Louis, The C.V. Mosby Co., 1952.)

Fig. 4-B: Operative scar is inconspicuous (Thoma incision).

The patient has had no recurrence of dislocation of the jaw since operation in September 1955 and has been free of symptoms, eating all types of food without restriction.

SURGICAL TECHNIQUE

With the patient under intratracheal anesthesia, the area anterior to the ear is draped so as to allow the anesthetist free access to the mouth under the sheets. This is of marked value during the operation, as will be described later. Xylocaine, 0.5 per cent (or procaine), containing eight drops of 1:1,000 adrenalin solution per thirty cubic centimeters, is infiltrated into the skin and subcutaneous tissues along the line of the incision, as well as into the temporomandibular joint, thirty to fifty cubic centimeters being used in all. This appreciably decreases the bleeding, which can be profuse in this region. The Thoma incision (Fig. 4-A) has been used routinely by us during the past five years for temporomandibular-joint surgery, and has been instrumental in almost eliminating the transient paresis of the forehead muscles due to traction. The incision must never extend below a point one-quarter of an inch above the lower ear-lobe attachment, in order to avoid injury to the facial-nerve trunk or parotid gland. The wound is deepened to the zygoma, and then the entire anterior flap is stripped forward on the zygoma en masse, avoiding exposure of or injury to the motor branches of the facial nerve. The capsule of the temporomandibular joint is exposed, and the capsule is incised transversely just below the margin of the zygoma, exposing the meniscus. The lateral border of the meniscus is grasped with a small clamp, and the posterior attachment is cut free with a small curved scissors. The anesthetist then pulls forward firmly on the lower jaw by inserting his padded fingers behind the lower teeth, under the drapes. This moves the mandibular condyle forward markedly, allowing the inner margin of the meniscus to be cut free with relative ease, and facilitates what ordinarily would be the most difficult phase of the operation. The anterior attachment

of the meniscus is then detached from the insertion of the external pterygoid muscle, and removed. The joint is inspected carefully for any remaining tags of meniscus, and, if any are found, they are removed. The anesthetist pulls the mandible forward at the request of the surgeon; this allows thorough inspection of the joint space. The insertion of the external pterygoid muscle on the anterior aspect of the mandibular condyle and neck is then identified, the upper half is picked up bluntly on a curved hemostat, and this portion is sectioned. Bleeding is controlled by intermittent packing with adrenalin-soaked pledgets and the use of suction. We have avoided the use of clamps and ligatures except in the subcutaneous-tissue layer, to prevent injury to the motor branches of the facial nerve. The joint capsule is closed with a few chromic catgut sutures, the subcutaneous tissues are approximated with fine plain catgut sutures, and the skin is closed with 0000 dermalon or ethalon sutures.

A small gauze pressure dressing is applied to the wound with elastoplast strapping. No drains are used.

POSTOPERATIVE CARE

The patient is allowed a soft diet on the day after operation, and is allowed to walk at that time. Sutures are removed on the third postoperative day, and the patient may be discharged at that time. After a few weeks, he increases the diet as desired. No special restrictions are imposed.

COMMENT

It is considered significant that roentgenograms of the temporomandibular joints in the case reported have shown persistence of limitation of the forward excursion of the mandibular condyle on the side operated on in the open-mouth view, almost four and one-half years after operation. This confirms the basic premise of the operative procedure, which is to reduce the forward muscle pull on the mandibular condyle, and, at the same time, to remove a potential mechanical block by meniscectomy.

In bilateral recurrent dislocation, excellent results have been reported as long as eight years after operation by surgery on just one side [4]. It would seem reasonable in bilateral dislocation to operate on the more painful side and let a sufficient period of time pass to determine whether operation on the other side might not be superfluous, since the limitation of motion on the side operated on invariably reduces the mobility on the untreated side of the mandible to some degree.

SUMMARY

Recurrent dislocation of the temporomandibular joint is an infrequent but disabling condition.

Surgical treatment is the only therapy of practical value in a well established condition.

Of the multiple surgical procedures available, we believe that partial section of the insertion of the external pterygoid muscle with meniscectomy is a relatively simple, reliable procedure. This was proposed originally by Boman in 1949.

A case is presented with five years' follow-up. No recurrence has occurred up to the time of writing, and the clinical result is considered good.

The surgical technique and aftercare are described.

REFERENCES

1. Ashhurst, A.P.C.: Recurrent Unilateral Subluxation of Mandible, Excision of the Interarticularis Cartilage in Cases of Snapping Jaw. Ann. Surg., **73**: 712–715, 1921.

2. Boman, Karl: A New Operation for Luxation in the Temporomandibular Joint. Acta Chir. Scandinavica, **99:** 96–100, 1949.
3. Bosworth, D.M.: Personal communication.
4. Foged, Jens: Habitual Dislocation of the Jaw Treated with Konjetzny's Operation. Acta Chir. Scandinavica, **105:** 78–91, 1953.
5. Gordon, S.: Recurring Dislocation of the Temporo-mandibular Joint. British J. Plast. Surg., **3:** 244–248, 1951.
6. von Hacker: Ueber die Verrenkung des Unterkiefers nach hinten, zugleich ein Beitrag zur Behandlung der habituellen Kieferverrenkung. Beitr. z. Klin. Chir., **52:** 748–780, 1907.
7. Konjetzny, G.E.: Die operative Behandlung der habituellen unterkieferluxation. (Eine neue Operationsmethode.) Arch. f. Klin. Chir., **116:** 681–692, 1921.
8. Lindemann, A.: Die chirurgische Behandlung der Erkrankungen des Kiefergelenks. Zeitschr. f. Stomatol., **23:** 395, 1925.
9. Mayer, Leo: Recurrent Dislocation of the Jaw. J. Bone and Joint Surg., **15:** 889–896, Oct. 1933.
10. Myrhaug, Hilmar: A New Method of Operation for Habitual Dislocation of the Mandible—Review of Former Methods of Treatment. Acta Odont. Scandinavica, **9:** 247–261, 1951.
11. Schultz, L.W.: A Treatment for Subluxation of the Temporomandibular Joint. J. Am. Med. Assn., **109:** 1032–1034, 1937.
12. Schultz, L.W.: Report of Ten Years' Experience in Treating Hypermobility of the Temporomandibular Joints. J. Oral Surg., **5:** 202–207, 1947.
13. Schwartz, Laszlo: Disorders of the Temporomandibular Joint. Diagnosis, Management, Relation to Occlusion of Teeth. Philadelphia and London, W. B. Saunders Co., 1959.
14. Silver, C.M.; Simon, S.D.; and Savastano, A.A.: Meniscus Injuries of the Temporomandibular Joint. J. Bone and Joint Surg., **38-A:** 541–552, June 1956.

Congenital Elevation of the Scapula

Correction by Release and Transplantation of Muscle Origins

A Preliminary Report *

BY JOE W. WOODWARD, M.D., WACO, TEXAS

It is the purpose of this article to describe an operative procedure for the correction of congenital elevation of the scapula. In this operation, lowering of the scapula is accomplished by release and transplantation of the origin of the muscles attached to the medial border of the scapula, combined with removal of the omovertebral bone and other limiting structures. To my knowledge the previously reported methods for the correction of this deformity have involved the release of the insertions of these muscles, rather than the origins.

In this deformity, the scapula is elevated, hypoplastic, and usually somewhat adducted. Almost without exception, there are associated anomalies of the cervical and thoracic spine, as well as the ribs. An omovertebral bone is found to be present in approximately one-third of these deformities. This osseous and cartilaginous structure extends upward and medially from the upper margin of the scapula to attach by either cartilaginous or fibrous tissue to the spinous process, lamina, or transverse process of one of the lower cervical vertebrae. The abnormal bar, occasionally in combination with a contracted or fibrous levator scapulae muscle, may limit motion of the scapula and thus decrease the range of abduction and the mobility of the shoulder girdle when compared with the normal side. If the omovertebral bone is attached high in the cervical spine, rotational movement of the neck may be limited, especially when other anomalies of the cervical spine are present. Even if there is no functional impairment, the appearance of this deformity may be sufficiently objectionable to create psychological problems.

REVIEW OF LITERATURE

The best-known operation for the correction of this deformity is the Schrock modification of the Putti procedure, in which the supraspinatus portion of the scapula and the omovertebral bone are resected, and the muscles attached to the scapula are released by a rather extensive subperiosteal dissection. The scapula, thus mobilized, is held down in the corrected position by wires or sutures that secure it to a rib or adjacent structure. The disadvantages of a subperiosteal release were stressed by Smith, who advised, for very young patients, the removal of the omovertebral bone or fibrous band without any attempt to lower the scapula.

The results of these procedures have been somewhat discouraging, as pointed out by Jeannopoulos, who reviewed thirty-five cases from the files of the New York Orthopedic Hospital. In these cases, treated in the main by the Schrock procedure, only one-half were considered to have satisfactory results and one-quarter had no improvement. In over 50 per cent of the cases reported, there was extensive regeneration of bone sufficient to cause an objectionable bulge at the base of the neck. Unsightly keloid scars were quite common, as was prominence of the inferior

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 27, 1960, and at the Meeting of the International Society of Orthopaedic Surgery and Traumatology, New York, N. Y., September 9, 1960.

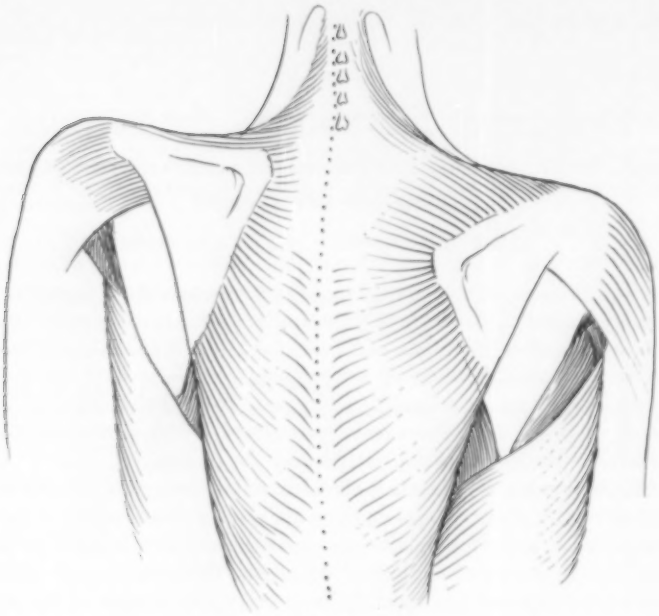


FIG. 1

Drawing illustrating the extensive origin of the trapezius muscle, which arises in the mid-line and is a key structure in the correction. A mid-line incision is made, extending from the spinous process of the fourth cervical vertebra distalward to the ninth thoracic vertebra.

angle or vertebral border of the scapula. In four of the patients there developed paralysis of the upper extremity secondary to overstretch of the brachial plexus, and in two patients, there was evidence of avascular necrosis of the scapula after operation.

More recently, Green described an extraperiosteal release of the muscles at their insertion into the scapula, with the supraclavicular portion of the scapula being excised. The muscles are then reattached to the scapula which is held down in a lower position by wire traction. This is produced by a spring scale attached to a spica cast used to immobilize the patient for three weeks. The results from this rather formidable procedure were rated as excellent.

The surgical method to be described herewith was devised to lessen the chance of complications and to offer a method with the advantage of simplicity.

OPERATIVE PROCEDURE

The patient is placed prone on the operating table, with the head supported on a craniotomy headrest so that the neck is in slight flexion. After surgical preparation of the skin, the arm on the involved side is draped so that both it and the shoulder girdle can be manipulated during the operation. A mid-line incision is made extending from the spinous process of the fourth cervical vertebra distalward to the ninth thoracic vertebra. The skin and subcutaneous tissues are undermined laterally on the involved side well out to the vertebral border of the scapula. This allows a better visualization of the muscle arrangement and makes possible lowering of the scapula without shifting the skin distalward with it. At the lower end of the incision, the lateral border of the trapezius is readily identified and should be separated from the underlying latissimus dorsi by blunt dissection. The origin of the trapezius is then removed from the spinous processes by sharp

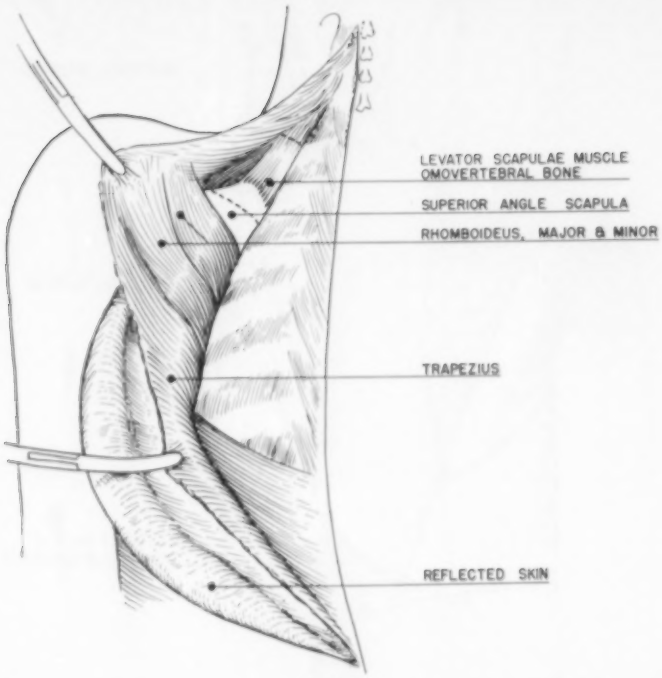


FIG. 2

Drawing illustrating the raised muscle sheet and, as the dissection is carried upward, the origins of the rhomboideus major and minor muscles are divided; the rhomboids are raised as a single sheet, with a well defined layer of deep fascia separating them from the erector muscles.

dissection. This origin is tough and tendinous, being capable of holding a suture quite well. As the dissection is carried upward, the origins of the rhomboideus major and minor muscles are identified and divided in a like manner. The rhomboids and the upper portion of the trapezius are separated from the serratus posterior superior and the sacrospinalis by a well defined layer of deep fascia. It is most important that the proper tissue plane be gained, since an intact aponeurosis or muscle sheet is essential for the successful fixation of the scapula in the corrected position.

When this muscle sheet has been removed from the spinous processes to the upper limit of the incision, the whole sheet can be retracted laterally to give access to the omovertebral bone or fibrous bands attached to the superior border of the scapula, if these are present. When removing the omovertebral bone, it is best to avoid subperiosteal dissection. It is suggested that a bone biter be used to remove this bone from the superior angle of the scapula, and its attachment to the cervical spine may be divided in a similar fashion. While carrying out this procedure, the spinal accessory nerve, which lies on the undersurface of the trapezius muscle in line with the vertebral border of the scapula, must be protected from overstretching or other injury. This important nerve, as well as the nerves to the rhomboids, is most likely to be injured during the removal of the omovertebral bone, or during the sectioning of a fibrous band or contracted levator scapulae muscle, when these are present.

Troublesome bleeding from the transverse cervical artery may also be encountered at the superior angle of the scapula if care is not taken to protect this vessel during the dissection.

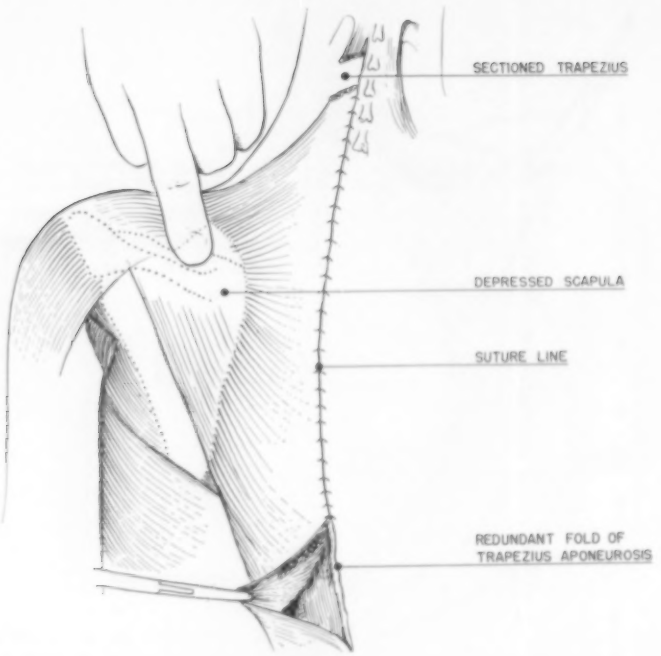


FIG. 3

Drawing showing that the muscle sheet has been sectioned above after release of the fibrous bands and omovertebral bone. Downward pressure on the scapula is maintained while the operator sutures the muscle origins at a lower level to maintain this shift. The fold of trapezius aponeurosis that was created at the lower end of the exposure is folded over or clipped off, using sutures to close the short transverse gap.

The supraspinous portion of the scapula may be enlarged and curved anteriorly to such an extent that it forms a prominence in the supraclavicular fossa. In such cases, this portion of the scapula should be removed without periosteal stripping, since if this beak of bone is not removed, it may impair movement of the scapula on the thorax after the scapula has been moved downward.

After the omovertebral bone or fibrous bands have been removed and the levator scapulae muscle has been released, the shoulder girdle becomes much more mobile. As a rule, the narrow portion of the trapezius still attached to the spine above the level of the fourth cervical vertebra will have to be sectioned at the level of the fourth cervical to permit sufficient downward displacement of the shoulder girdle. Once this has been accomplished, the shoulder girdle and the muscle sheet, composed of the trapezius and rhomboid muscles, can be moved caudally without undue force until the spine of the scapula on the affected side comes down to about the same level as that of the scapular spine on the opposite side. In doing this, it should be remembered that the scapula involved is frequently smaller than the one on the normal side. An attempt to bring its inferior angle down to the level of that on the normal side would bring about overcorrection and without fail create disturbing changes in the brachial plexus. While the scapula is maintained in the corrected position by the assistant, the surgeon reattaches the tough aponeurosis of the trapezius and rhomboids in its new position. This is sutured in the same way that an incision for a laminectomy is closed, working from above downward. As the suturing proceeds, a fold is created, since the origin of the trapezius muscle from the level of the ninth thoracic vertebra downward is not disturbed. This re-

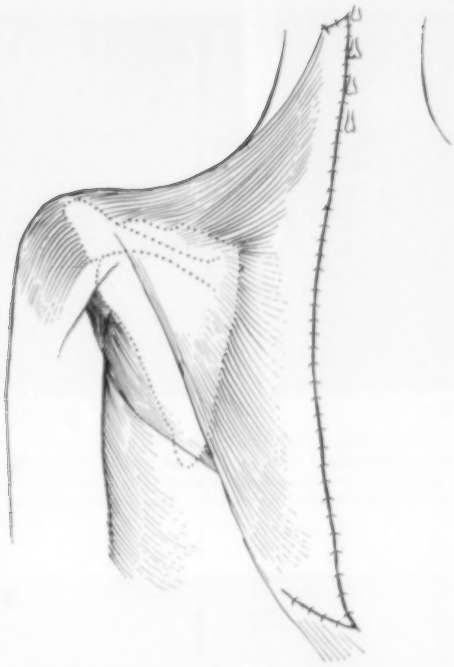


FIG. 4

The final closure of the muscle structures is shown. It is most important to do a meticulous closure of subcutaneous tissue and skin in order to minimize distressing keloid formation or broadening of the scars.

dundant tissue is largely composed of aponeurosis and may be folded over or clipped off, with sutures used to close this short transverse gap. Although bilateral deformity has not been treated by this method, it is anticipated that sutures to reattach the two aponeuroses could be passed through the spinous processes and interspinous ligaments to anchor the scapulae in the corrected position. It has not been found necessary to release the portion of the trapezius attached to the clavicle, and the serratus anterior has not prevented depression of the shoulder girdle. Fibrous bands attached to the anterior surface of the scapula may restrict downward displacement of the shoulder girdle; and, if found, they should be sectioned. The nerves supplying the trapezius and rhomboid muscles will accommodate to the downward displacement; they need not be identified, but their location should be kept in mind constantly, to avoid injury to them during the dissection. The skin and subcutaneous tissue should be closed with meticulous care to minimize the tendency to keloid formation and the spreading of the scar in the region where the stresses on the skin are great.

The average duration of the nine surgical procedures reported herein was one hour and forty-five minutes. Excessive bleeding was not encountered and shock did not develop in any patients.

A cloth Velpeau bandage should be applied and worn for approximately fourteen days to aid in the comfort of the patient and to prevent young children from being too active. Walking is permitted promptly; hospitalization beyond five days is generally unnecessary.

COMPLICATIONS

In one instance paralysis and partial loss of sensation in the affected limb

FIG. 5-A

FIG. 5-B

Figs. 5-A through 5-C: A boy with extreme deformity.
Fig. 5-A: Preoperative roentgenogram when the patient was fourteen years old.
Fig. 5-B: The oblique preoperative roentgenogram shows the broad omovertebral bone attached to the fourth cervical vertebra; this created severe limitation of neck rotation and limited shoulder abduction at 100 degrees.

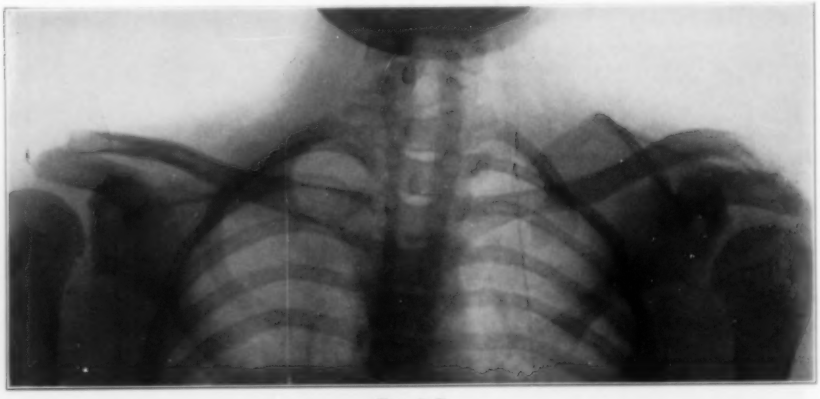


FIG. 5-C

Two years after surgery there is improvement in shoulder abduction of 70 degrees, allowing such sports activities as the crawl swimming stroke.

were discovered after operation. Full return of muscle power and sensation was complete in six months. In this patient, the scapula was pulled down until the inferior angles of the two scapulae were at the same level. For this small and underdeveloped scapula, considerable overcorrection was thereby brought about, with resultant excessive traction on the brachial plexus.

The only other complications were spreading of the scar and a tendency toward the formation of keloids; three of the scars were wide and unsightly.

RESULTS

Nine patients with congenital elevation of the scapula were treated by the procedure described. The operations were performed by myself and five other surgeons who have graciously contributed their cases to this series. The longest follow-up was five years, and the shortest was nine months; the average follow-up was two years and six months. The results in these cases are shown in Table I.

TABLE I

DATA ON SURGICAL TREATMENT

Case	Age (*Years*)	Race	Sex	Omovertebral Bone Present	Length of Follow-up (*Years*)	Preoperative Shoulder Abduction Capacity (*Degrees*)	Postoperative Shoulder Abduction Capacity (*Degrees*)	Supraspinous Bone Removed	Amount of Scapular Lowering (*Centimeters*)	Loss of Scapular Position	Regeneration of Bone	Complications	Remarks
1	14	Caucasian	M	Yes	5	100	170	Yes	7	None	None	Broad scar; several buried silk sutures extruded	Marked improvement in social adjustment; sports performance now above average; excellent swimmer
2	6	Caucasian	M	No	3 5/12	180	180	No	5	None	None	None	Upper thoracic curvature showed improvement in latest postoperative roentgenograms
3	12	Negro	F	No	3 5/12	135	165	No	8	None	None	Partial sensory and motor loss requiring 6 mos. to clear	Overcorrection by matching inferior angles; curvature improvement noted
4	5	Caucasian	F	Yes	2 5/12	130	170	Yes	4	None	None	None	None
5	4	Negro	F	Yes	1 5/12	130	165	No	4 1/2	None	None	Keloid area in upper portion of the scar	None
6	7	Negro	F	Yes	1 3/12	145	170	Yes	4	None	None	Small keloid area	None
7	2 1/2	Caucasian	F	Yes	10/12	140	180	No	4	None	None	None	Many heavy bands connecting scapula and ribs released, as well as the omovertebral bar
8	14	Caucasian	M	No	9/12	150	180	No	5	None	None	None	Patient quite active in baseball; pleased with cosmetic improvement
9	6	Caucasian	F	No	9/12	150	170	No	6	None	None	None	Operator was fearful of brachial palsy and lowered scapula 6 cm. of 10-cm. elevation; additional lowering could have been done

FIG. 6-A

A seven-year-old child before operation.

FIG. 6-B

Six months after operation.

FIG. 7-A

A six-year-old child before operation.

FIG. 7-B

Four months after operation.

DISCUSSION

The ideal time to do this procedure would appear to be when the patient is between the age of three and five years in order to ensure a more normal development of shoulder breadth on the affected side. Correction of the deformity in infants and children under the age of three by the technique described would have some advantages, but identification of the tissue planes and anatomical structures

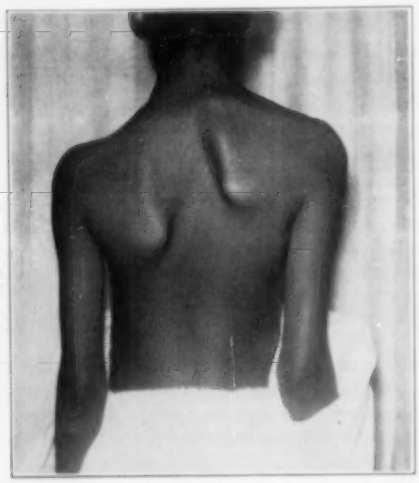


FIG. 8-A

A twelve-year-old girl before operation.

FIG. 8-B

Two years after operation.

would be somewhat more difficult at this age. A factor to be considered is that if the deformity is allowed to persist until a later age, it may interfere with the child's social adjustment. Additional experience with the procedure is needed to establish the ideal time for correction.

Although all our results were not entirely satisfactory, they have been most encouraging. No regeneration of bone has been encountered in any patient. In each case, definite improvement in the position of the scapula was maintained. The improvement in the contour of the shoulder was offset somewhat by the broad scars and occasional keloids that occurred, but all the parents were pleased by the improvement in the children's appearance. There was no functional impairment as a result of the operation. All children were able to elevate, depress, adduct, and rotate the scapula on the side of operation in a nearly normal fashion. In those children with limitation of shoulder abduction motion before operation, an increase in abduction ranging from 20 to 70 degrees was obtained.

The number of cases in this series is relatively small, and the follow-up is too short for a final evaluation of this method. However, it can be stated that in each child there has been improved function of the neck and shoulder, as well as an improved appearance. The procedure is believed to offer the advantage of simplicity, with a minimum chance for the regeneration of bone or circulatory disturbance of the scapula; the risk of permanent or temporary weakness of the shoulder girdle is also minimized.

SUMMARY

A procedure for the correction of congenital elevation of the scapula is described, in which correction is obtained by moving the origins of the trapezius and rhomboids downward after resection of the omovertebral bone or other fibrous bands. No muscles are stripped from the scapula. The preliminary results in nine patients have been encouraging; there was no regeneration of bone, and there was good function of the shoulder. In one patient, transitory brachial palsy developed when too much correction was attempted.

REFERENCES

1. GREEN, W. T.: The Surgical Correction of Congenital Elevation of the Scapula (Sprengel's

Deformity). *In* Proceedings of The American Orthopaedic Association. J. Bone and Joint Surg., **39-A:** 1439, Dec. 1957.
2. Jeannopoulos, C. L.: Congenital Elevation of the Scapula. J. Bone and Joint Surg., **34-A:** 883–892, Oct. 1952.
3. Schrock, R. D.: Congenital Elevation of the Scapula. J. Bone and Joint Surg., **8:** 207–215, Jan. 1926.
4. Smith, A. DeF.: Congenital Elevation of the Scapula. Arch. Surg., **42:** 529–536, 1941.

DISCUSSION

Dr. William T. Green, Boston, Massachusetts: The author has presented a new procedure designed to correct Sprengel's deformity. One must approach the shift of the scapula by disconnecting muscles at one end or the other. The author has chosen to disconnect the trapezius and the rhomboids from their origin from the spinous processes. I am interested that the author has found no need to change the relationship of the serratus anterior to the scapula nor any reason to remove the hooked supraspinous portion of the scapula in those scapulae that are severely deformed.

In his nine cases, the author recounted that the amount of scapular lowering was good to excellent, the cosmetic results were fair to good, and the functional improvement was quite satisfactory. One would like to know about the results in these patients in more precise terms. Results in this condition depend on the degree of original deformity, the anomalies of the muscles connected to the scapula, and other variables.

I have not performed the procedure that the author describes, but have followed another technique. I agree with the author that subperiosteal dissection is undesirable and have chosen to disconnect the muscles connecting the scapula to the trunk at their insertion into the scapula, carefully marking them as they are detached. The scapula is then displaced cephalad, and the muscles are reattached to the scapula so that their direction of pull will hold the scapula in the new position and at the same time control the scapula in the desired functional activity. There is great advantage to being in a position to reattach these muscles to the scapula, inasmuch as there are many related muscular abnormalities in this condition, and one is able to adjust the muscle structure so as to get the maximum function. If there is reasonable muscle structure, one expects to obtain, after this procedure, an essentially normal appearance and function. We reported sixteen procedures in June 1957, with a follow-up examination in one patient of as long as thirteen years. Since that time we have performed ten more operations. We are more enthusiastic about this procedure now than we were at the time of the original report.

I shall continue to do the procedure that we have performed in the past, but I look forward to Dr. Woodward's reporting further experience with his procedure. Whenever operation is performed, it should be remembered that brachial paralysis may occur, as happened in one of Dr. Woodward's patients, lasting as long as six months. He attributed this to too much displacement distally. We, too, in our twenty-six cases, have had one case of transient brachial palsy of shorter duration, with complete recovery, that we ascribed to too much traction. This experience should be a warning against overenthusiasm. We have had no untoward experiences in our cases.

I might say that the author could finish disconnecting the trapezius and bring its entire origin distalward, with the idea that the lower portion might hold the scapula in position and the trapezius might then function in a more normal relationship to the scapula.

The Surgical Treatment of Injuries of the Fibular Collateral Ligaments of the Ankle

BY CHARLES J. RUTH, M.D., FREMONT, CALIFORNIA

A sprained ankle may be a serious and disabling injury. Conventional methods for the treatment of injuries of the fibular collateral ligaments of the ankle consist in taping, strapping, or plaster immobilization for from two to four weeks. Results obtained with these methods leave much to be desired. There is need for a clearer understanding of the pathological lesion that is usually passed off as "just a sprain" when routine roentgenograms of the ankle are negative.

It is the purpose of this report to present in detail the pathological changes, a method of diagnosis, a technique of repair, and a comparison of the results of conservative and operative treatment in a large series of cases.

The literature is remarkably lacking in information concerning ankle sprains. Both Aufranc and Cave stated that of all the ligamentous injuries, those of the ankle, especially the fibular collateral ligaments, are the most common and least understood. They also noted that these injuries are often poorly managed and suggested, as did Anderson and LeCocq[1], that primary surgical repair may be needed if there is a complete tear of the ligaments. A considerable difference of opinion exists as to the nature of the damage, the importance of each of the three fibular collateral ligaments, and the best course of treatment to pursue for a sprained ankle [1,2,4,5,7,8,10,11,12,14,15,16,17,18,21,23,24,25,26].

I became interested in the surgical repair of ankle ligaments while in the Army. It was there that it became obvious that after conservative treatment of sprains of the ankle, men were often unable to perform their usual duties and reported on sick call frequently because of chronic disability resulting from their ankles. These men complained of "chronic sprains", weak ankles, giving way, swelling, and considerable aching with even mild activity.

The study presented here was instigated because of this high incidence of disability. The findings demonstrate that the principles outlined by O'Donoghue (and by Clayton and Weir, in dogs) concerning the repair of ligamentous injuries of the knee apply equally well to injuries of the fibular collateral ligaments of the ankle.

ANKLES TREATED BY SURGICAL REPAIR OF THE LIGAMENTS

The patients in this series included both sexes, ranging in age from seventeen to fifty years, but for the most part they were men between seventeen and thirty who were involved in active military duty. Each patient was checked by me regarding every fact presented in this paper except for the end results in a few instances in which the data from questionnaires were used.

Each patient was questioned carefully about the details of his injury and any previous disability with the ankle. The injuries varied from a slight twist on a pebble to a fall from a height of eight feet (Table I). Despite this, all injuries caused essentially an equal amount of damage, as seen at surgery in forty-five ankles.

Physical Findings

Each sprained ankle had a swelling larger than two by three centimeters which, most frequently during the first half-hour after injury, was located an-

terolaterally over the fibulotalar joint. A day or two after the injury, the skin became quite purple on the outer side of the heel or foot, depending on the position of the foot since the injury.

A blunt instrument, such as the end of the handle of a fountain pen, was used to probe the entire ankle area for localized tenderness. The site of a tear in the ligaments, as verified at surgery, could be very accurately determined by the location of maximum tenderness. No ankle was included in this series that had

TABLE I

TYPES OF INJURY CAUSING TEARS OF BOTH FIBULAR COLLATERAL LIGAMENTS IN THE FORTY-FIVE ANKLES TREATED SURGICALLY

Injury	No. of Ankles
Twisting the ankle:	
Without falling	20
With falling	11
Falling from a height of:	
One foot	2
One to three feet	4
Three to five feet	3
Five to eight feet	2
Automobile accident	3

any fracture (except for one avulsion fracture of the tip of the fibular malleolus) or any tenderness or laxity of the deltoid ligament.

Every ankle was partially anesthetized by a peroneal-nerve block with five to ten cubic centimeters of 1 per cent novocain or one-sixth of 1 per cent xylocain. Occasionally, the lateral aspect of the ankle was infiltrated slightly. The ankle was then checked for stability of the talus in the ankle mortise, with the foot in its loosest position, usually 20 to 30 degrees of plantar flexion. Inversion stress was applied to the calcaneus, directly below the fibula. The left hand was used to hold

FIG. 1

Anteroposterior roentgenogram of an ankle under inversion stress showing the abnormal opening, with torn calcaneofibular and anterior talofibular ligaments.

the right ankle, while the right hand grasped the heel and inverted it. The grip was reversed for the left ankle. Every ankle in this series showed abnormal mobility on manipulation, as compared with the opposite, normal ankle. Anteroposterior roentgenograms were made while stress was applied with the ankle inverted as far as possible.

The degree of mobility varies in different feet. The inversion stress should be applied directly to the lateral side of the heel, instead of merely holding the fore part of the foot and twisting it. With adequate analgesia, in the presence of a ruptured fibular collateral ligament, very little force is needed to invert the talus in the mortise and demonstrate the instability on roentgenograms.

At surgery, with the patient under general anesthesia, each ankle was checked for stability in all directions. Every injured ankle, with the physical signs listed previously, was observed to open quite loosely on the lateral side, as compared with the uninjured side. No roentgenograms were made at surgery.

FIG. 2

The opening of the tibiotalar joint is measured in millimeters by subtracting the normal distance *A* from the abnormally opened distance *B*.

Roentgenographic Findings

The degree of opening or tilting of the talus, with respect to the distal tibial articular surface, was measured directly as the distance in millimeters between the two clearly defined lines of subchondral bone in the talus and tibia on the lateral side of the joint (Fig. 2).

Lateral roentgenograms were obtained of the first ten ankles while the foot was in forced equinus position. No anterior subluxation of the talus was demonstrated; therefore, this procedure was eliminated as being inconclusive. Anderson and associates [2] demonstrated anterior subluxation of the talus in sprained ankles by this manipulation. Watson-Jones said he had seen only two cases of recurrent forward dislocation of the talus.

In the first thirty-five patients the stability of the ankle on the normal side was studied by making anteroposterior roentgenograms of that ankle while it was forced into painless inversion stress. In thirty-two previously uninjured, asymptomatic ankles the joint space opened less than two millimeters, whereas in three with previous injuries the space opened four to five millimeters on the lateral side. These three ankles caused moderate disability. From these figures an opening of up to two millimeters was considered normal. As was seen later at surgery, any freshly injured ankle that opened three millimeters or more proved to have a

complete rupture of both the calcaneofibular and the anterior talofibular ligaments.

Before operation all the ankles that were demonstrated to have torn ligaments at operation showed from three to ten millimeters of opening of the lateral joint space during stress testing, with most of them in the five-to-eight-millimeter range (Chart I).

Several factors influence the amount of measurable opening seen on roentgenograms. These include the other tissues that limit opening beyond eight millimeters; apprehension and voluntary resistance of the patient; effectiveness of the local-anesthesia block; strength and skill of the physician stressing the ankle; and the timing of the roentgenogram with respect to the application of the stress.

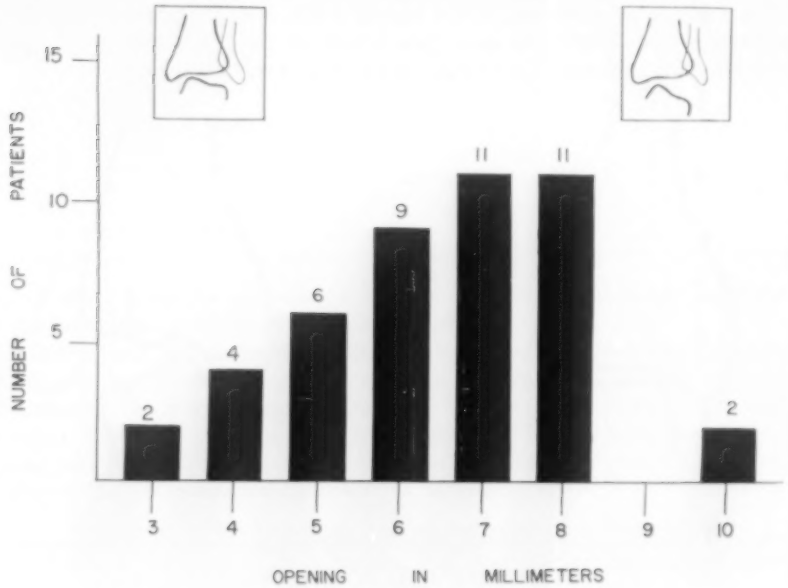


CHART I

Opening in millimeters of the tibiotalar joints, as shown during stress testing under local analgesia, in the forty-five ankles with tears of both ligaments.

Anatomy

The fibular collateral ligaments in the forty-five ankles treated surgically and in thirty dissected specimens showed great variations, especially in the size, shape, and direction of the calcaneofibular ligament (Fig. 3). This ligament varied from a cordlike structure four millimeters in diameter to a fan-shaped band of tissue with its apex attached to the fibula and its base attached to the calcaneus. Usually, the ligament was a band about six millimeters wide with its long axis angled from 10 to 45 degrees posteriorly from the long axis of the fibula. The anterior talofibular ligament was usually five millimeters wide and twelve millimeters long. The posterior talofibular ligament was rather constant; it was about six millimeters in diameter and nine millimeters long on its articular surface. The talocalcaneal ligament was usually short and, in sixty-nine of the seventy-five ankles examined, it was attached low on the talus.

Ashhurst and Bromer and Anderson and LeCocq [1] commented on the great strength of the posterior talofibular ligament, as evidenced by the infrequency with which it is torn in an ankle injury. I agree that it is a large structure, but I

also feel that it is infrequently injured because it is seldom subjected to great stress. Greatest stress on this ligament occurs when the foot is forced into extreme dorsiflexion and inversion or when complete dislocation of the ankle occurs.

Pathological Findings

In forty-four of the forty-five ankles treated by open operation there was a single continuous fresh tear involving the calcaneofibular and anterior talofibular ligaments, the capsule between these ligaments, and the anterior capsule of the ankle joint (Fig. 4-A). The ends of the torn ligaments were separated by from five to fifteen millimeters, with torn capsule and fatty tissue interposed between the ends of the ruptured ligaments. No positioning or manipulation of the foot or ankle at operation was successful in reapproximating the torn ends of the liga-

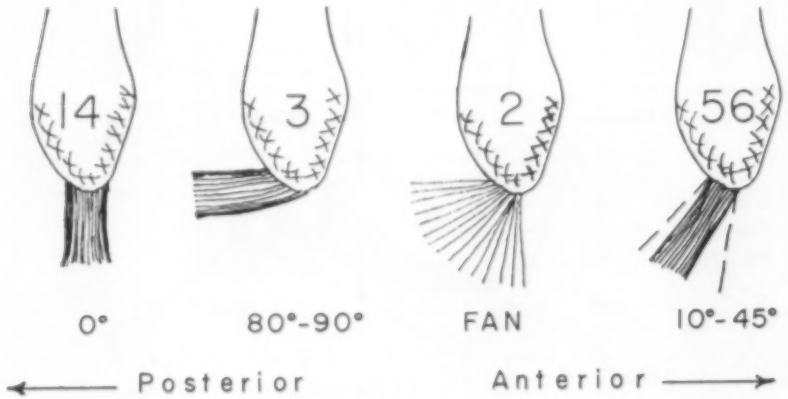


FIG. 3

The anatomical variations of the calcaneofibular ligament in seventy-five ankles, of which forty-five had been operated on. The remainder, thirty ankles, were anatomical specimens.

ments. The variations in location of tears are shown in Figure 4-B. Five were at the distal ends of both ligaments, seven at the proximal ends, and twenty through the mid-portions of both ligaments. In thirteen, the tears involved both the ends and mid-portions of the two ligaments. In only one injury had an avulsion fracture occurred leaving the ligament intact. These observations differ from those of studies made on both patients and cadavera [1,2,5,13,16,21].

One of the ankles treated by open repair had had a previous injury of unknown nature. At operation both ligaments showed an area of tough fibrous scar about three millimeters long in the central portion. The recent injury had torn each of the ligaments in a new place. There were no loose bodies of bone or cartilage in any of the ankle joints explored.

Surgical Technique

Surgical repair of ankle ligaments is not a procedure to be undertaken lightly; there are many pitfalls.

The incision (Fig. 4-C) should be long enough to permit examination of both the calcaneofibular and the anterior tibiofibular ligaments without forcible retraction of any of the tissues. The incision should be curved at each end, but its mid-portion should be straight and in line with the creases in the skin to keep the flap as short as possible. Gentle dissection should follow the course of the hematoma, as this leads easily through tissues that are already torn. The anterior talofibular

ligament should be examined first. If the calcaneofibular ligament is torn only in its proximal portion, the posterior part of the incision is not needed. However, the calcaneofibular ligament must be identified without fail, as it may be angled as far back as 90 degrees from the long axis of the fibula. The inner aspect of the posterior talofibular ligament can be seen by opening the joint; if it is torn, additional exposure is needed for repair. The distal one centimeter of the anterior tibiofibular ligament can usually be seen without extending the incision, and should be examined and repaired if necessary.

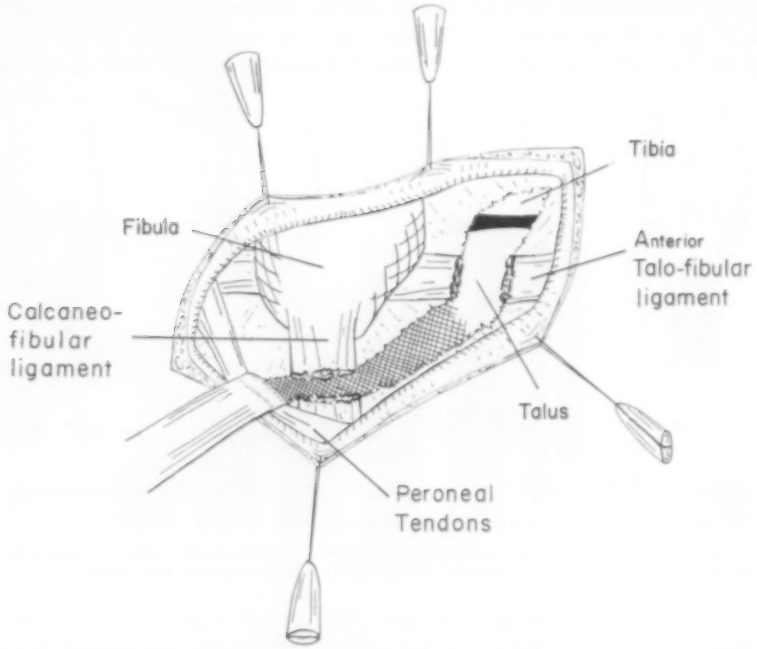


FIG. 4-A

Figs. 4-A, 4-B, and 4-C: Extent of damage, incidence of fresh tears, and location of incision in forty-four ankles treated by surgery.
Fig. 4-A: Extent of damage.

After thorough irrigation of the wound with normal saline solution and careful identification of all structures, the wound is closed in layers, starting at each end of the tear, working toward the middle, and placing all sutures in the ligaments and the capsule before any is tied. Two-zero chromic catgut, figure-of-eight sutures are used to accomplish anatomical approximation of the torn ends. The foot is held carefully at 90 degrees with slight eversion as the sutures are tied. The tourniquet is removed before the wound is closed to allow the superficial vessels to refill with blood. Pressure must not be applied to the wound with either dressings or cast before the tourniquet is removed, since the vessels supplying the skin and subcutaneous tissues may never refill with blood and the skin may slough.

A plaster boot is applied with the foot in this position, being sure the plaster is completely set before anesthesia is discontinued. The cast should be bivalved and the dressing should be changed in twenty-four hours to examine the skin edges and to remove any dressing hardened by dried blood. Hard dressings may press on the skin and cause necrosis of the skin. A short walking cast is applied seven to ten

days after operation; weight-bearing is allowed about ten days after surgery, usually with crutches for the first few days. Plaster immobilization is maintained for six weeks after surgery.

This primary repair is simpler and more effective than late reconstruction using the peroneus brevis tendon after failure of conservative therapy.

ANKLES TREATED BY IMMOBILIZATION IN PLASTER

When an attempt was made to compare the results from primary surgical repair with those following simple plaster immobilization, it soon became obvious

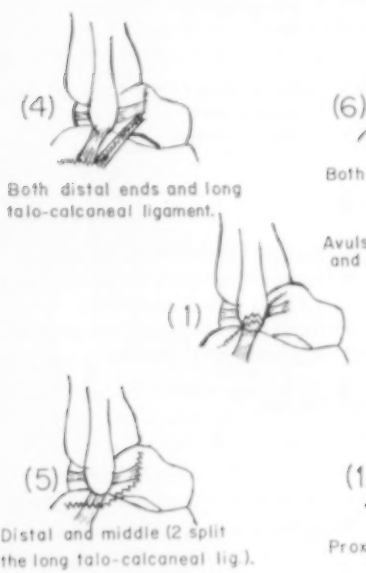


FIG. 4-B

Anatomy and incidence (in parentheses) of fresh tears.

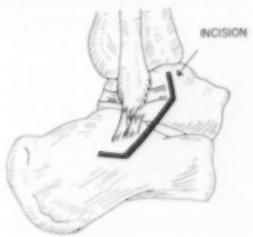


FIG. 4-C

Anatomy and location of the incision.

that there was insufficient material in the literature to provide a true evaluation. No article details adequately the criteria either for the diagnosis of ligamentous tear or for the end-result evaluation. What little has been written on this subject has been based primarily on animal and cadaver experiments [2,5,13,16,17,18,21], cutting the different ligaments in sequence in an attempt to use the resulting angle of the tilt of the talus under stress as a means to determine which ligaments may be involved in a freshly injured ankle.

For comparison, it was necessary to obtain a suitable series of ankles that had not been operated on. Therefore, I treated 190 sprained ankles by only six weeks of immobilization in plaster. These ankles showed all the previously listed clinical signs of ligamentous rupture and, when tested by stress roentgenograms with a peroneal-nerve block, an opening of more than three millimeters of the lateral joint space. The patients were unselected and were comparable with those treated by open surgical repair in all respects—age, sex, type of injury, and functional demands after treatment.

After the plaster cast was removed, elastic bandages, exercise, active motion, warm soaks, and gradually increased activity were utilized to regain motion and strength.

TABLE II

END RESULTS IN NINETY-FOUR ANKLES EXAMINED BY THE AUTHOR AND TEN ANKLES EVALUATED BY THE PATIENT IN A QUESTIONNAIRE

ANKLES SURGICALLY TREATED *

No. of Ankles Examined by the Author	No. of Ankles Evaluated by the Patient in Questionnaire	Time after Surgery (*Years*)	Clinical and Roentgenographic Appearance	Symptoms	End Result (Return of Function)
9		2½	Stable		Normal
13		2½	Stable	Occasional mild aching and fatigue	Over 90 per cent normal
	7	2½			Over 90 per cent normal
	1	2½		Ankle resprained, taped, 1 wk.; ankle aches and gives way	75 per cent normal
	1	2½			50 per cent normal; patient is machine operator and on feet 10 hrs. a day
	1	2½		Can play only nine holes of golf	V.A. disability of 40 per cent for ankle

Summary: 29 of 32 patients had normal function or very good results, and two had from 50 to 75 per cent normal function. Only one ankle caused any significant disability.

ANKLES CONSERVATIVELY TREATED **

No. of Ankles Examined by the Author	Time after Injury (*Years*)	Clinical and Roentgenographic Appearance	Symptoms	End Result (Return of Function)
23	2	Stable	Moderate aching	75–80 per cent normal
24	2	Stable		Over 90 per cent normal
6	2	Opening of 3 to 4 mm.; slightly loose		Over 90 per cent normal
19	2	Opening of 3 to 4 mm.; slightly loose	Moderate aching	78–80 per cent normal

Summary: 30 of 72 patients had normal function and no aching; 42 had moderate aching. All ankles functioned and were durable.

* In addition to surgery, the ankles were immobilized in a plaster cast for six weeks. The patients were hospitalized for from four to seven days; weight-bearing was allowed in ten days.

** These ankles were immobilized in a plaster cast for six weeks. Hospitalization was from zero to seven days; weight-bearing was allowed from the first to seventh day.

END RESULTS

The end results in the two groups of cases are summarized in Table II. Of the forty-five patients whose ankles were treated by open repair twenty-two were re-examined after two and a half years and ten replied to questionnaires. Seventy-two of the 190 ankles treated by immobilization were available for re-examination after two years.

Of the thirty-two surgically treated ankles that were followed, only three caused more than minimum symptoms and in two of these (both evaluated by questionnaire) it would appear that the symptoms were, in fact, minimum. All of the surgically treated ankles that were re-examined were stable.

Of the conservatively treated ankles that were re-examined, no patient had more than moderate aching and all had satisfactory function. However, only two-

thirds of the ankles proved to be stable and of these stable ankles only 50 per cent were normal. More than one-third of the re-examined, conservatively treated ankles were mildly unstable, but one-quarter of these unstable ankles were found to be functionally normal.

COMPLICATIONS

Early in the series there were three consecutive cases of superficial wound necrosis caused by ischemia of the skin flaps. These were treated with plaster immobilization, until they were healed (eight weeks after operation in each instance), by antibiotics, warm soaks, and elevation. Eventually, these three ankles were more stable than most of the others. Skin loss can be avoided almost invariably by careful handling of the tissues at surgery and by changing the dressings twenty-four hours after operation.

In one patient there were four branches of the sural nerve. The fourth branch was divided inadvertently after the other three had been identified. The nerve was repaired at once, and within six months the resulting slight hypesthesia had disappeared.

DISCUSSION

The disadvantages of open surgical repair include the necessary four to seven days of hospitalization and the risk of infection, slough of skin, reaction to anesthesia, or surgical accidents.

The advantage of open repair is the assurance of having a functionally stable, essentially normal ankle, capable of heavy duty, with no more than occasional mild aching and slight limitation of motion.

Many of the ankles treated only by immobilization in plaster required five to seven days of hospitalization with bedrest and elevation of the leg before a walking cast could be applied and walking with crutches started. Some of the ankles with moderate swelling were immobilized in plaster at once and the patient became quite comfortable in a few hours. Under these circumstances the patients lost no time from light activities. Even the patients with severely swollen ankles rapidly became comfortable when plaster immobilization was employed. With either closed or open treatment, painless walking and light work, while seated, were possible within two weeks of injury.

If the measured angles of the tilt of the talus alone were used to establish the diagnosis of the damage in a swollen ankle, a general anesthetic and roentgenograms with the foot in various positions of stress would be required for every patient. This would involve too much anesthesia and too much irradiation, especially for the physician. Therefore, the physical signs and clinical stability of the ankle, as determined after local nerve block, must be employed to obtain enough information to determine the diagnosis and appropriate treatment. The signs herein listed were associated with fresh tears of both ligaments in forty-four of the forty-five ankles operated on. The one exception was an ankle that had all these signs, but had been injured previously. In this ankle the two ligaments were lax as the result of old trauma; the fresh hemorrhage and swelling came from a torn anterior tibiofibular ligament. This was the only tear of this ligament found in the forty-five ankles operated on.

Many other so-called sprained ankles were seen during the time this study was in progress. These were not included in this series because the joint spaces in these ankles did not open under stress and they did not have the amount of swelling or pain that I listed. In all of these cases the symptoms cleared rapidly within five days, with no more treatment than rest and elastic bandage or taping.

It is just as important to examine an injured ankle as it is to examine an injured knee, an acute condition within the abdomen, or a draining ear. If pain interferes with the examination within the first few days after injury, adequate anesthesia should be employed. The surgeon should not miss the opportunity to repair these ligaments within five days of injury, when these structures are easily identified and sutured.

After one has examined many ankles with instability proved by stress roentgenograms under anesthesia, it becomes quite easy to diagnose torn ankle ligaments accurately. When inversion stress is applied to the hind part of the foot there is no mistaking the palpable click of an unstable talus with torn lateral collateral ligaments as it inverts in the mortise.

To round out this study, fifty similarly sprained ankles should have been treated with taping, injections, or massage, as well as more than six weeks of immobilization in plaster. Even though this evidence is lacking I believe that injection for the relief of pain in an area of ligamentous rupture will not shorten the healing time of the ligament in any way whatsoever. Similarly, it seems most unlikely that strapping with adhesive tape can provide sufficient immobilization to ensure satisfactory healing of the ruptured ligaments. Plaster immobilization for longer than six weeks did not produce better results in some twenty ankles that were examined by me six to twelve months after they had been treated elsewhere. Evidence in the literature indicates that most damaged ligamentous tissue in the body heals within six weeks, and that further rigid immobilization is not necessary [9,20]. Although some individuals' ligamentous tissues may heal in less than this time, it is impossible to select these individuals beforehand. Böhler noted a higher incidence of poor results in ankles that did not appear to be badly injured at first than in those that did appear to have been severely injured initially. This he attributed to the shorter immobilization of the ankles with seemingly less severe injuries during initial treatment. After secondary reconstruction of the ligaments in this area, Watson-Jones immobilized the ankle for eight weeks, Anderson and LeCocq [1] for six weeks.

There are many unstable ankles that are the end result of inadequately treated sprains. These ankles give way repeatedly and have roentgenographic evidence of instability and traumatic arthritis. Bonnin [6], in a survey of a large number of ankles, found that 5 per cent were unstable from old injuries. Hughes found a 25 per cent recurrence of subluxation following old injuries. In contrast to these results, at least twenty-nine and probably thirty-one of the thirty-two ankles in this series that were treated by open repair and followed for two and a half years after operation have practically normal function.

It would appear that a so-called sprained ankle is an all-or-none injury. It is either a mild stretch of tissue which heals with rest or taping in less than five days or it is a complete dehiscence of at least the two anterior parts of the fibular collateral ligament, requiring six or more weeks of complete immobilization in plaster for proper healing. There are cases where pain disappears in less than six weeks without plaster immobilization, but this is no proof that the ligaments have healed properly.

SUMMARY

In a series of 235 freshly sprained ankles with roentgenographic proof of instability of the fibular collateral ligaments, forty-five were repaired surgically and then immobilized in plaster for six weeks; 190 were immobilized in plaster for six weeks without surgery. Thirty-three of the ankles treated by open ligamentous repair were followed for two and a half years. Twenty-nine of these regained 90 per cent or more of normal function.

Seventy-two of the 190 ankles treated by immobilization in plaster for six weeks were examined two years after injury. Only thirty showed a 90 per cent or better return of function, whereas the remaining forty-two had a 75 to 80 per cent return of function with occasional swelling, giving way, aching, and weakness during moderate activity.

CONCLUSION

Surgical repair is indicated in a sprained ankle if during the rest of his life the patient will need a painless, stable ankle adequate for heavy duty.

There is only one satisfactory non-operative treatment for an ankle with torn ligaments: immobilization in plaster for at least six weeks.

If the physician decides against operative treatment or immobilization in plaster, he should first have proof that the ligaments are intact and that the ankle is stable.

REFERENCES

1. Anderson, K. J., and LeCocq, J. F.: Operative Treatment of Injury to the Fibular Collateral Ligament of the Ankle. J. Bone and Joint Surg., **36-A:** 825–832, July 1954.
2. Anderson, K. J.; LeCocq, J. F.; and LeCocq, E. A.: Recurrent Anterior Subluxation of the Ankle Joint. A Report of Two Cases and an Experimental Study. J. Bone and Joint Surg., **34-A:** 853–860, Oct. 1952.
3. Ashhurst, A. P. C., and Bromer, R. S.: Classification and Mechanism of Fractures of the Leg Bones Involving the Ankle. Based on a Study of Three Hundred Cases from the Episcopal Hospital. Arch. Surg., **4:** 51–129, 1922.
4. Aufranc, O. E.: Ankle Injuries, p. 582. *In* Fractures and Other Injuries. Edited by E. F. Cave. Chicago, The Year Book Publishers, Inc., 1958.
5. Böhler, Lorenz: The Treatment of Fractures. Vol. 3, pp. 1993–2000. Ed. 5. Translated from the thirteenth German edition by Alfred Wallner and Otto Russe. New York, Grune and Stratton, 1958.
6. Bonnin, J. G.: The Hypermobile Ankle. Proc. Roy. Soc. Med., **37:** 282–286, 1944.
7. Bonnin, J. G.: Injuries to the Ankle. New York, Grune and Stratton, 1950.
8. Cave, E. F.: Treatment of Ankle Injuries. GP, **15:** 85–93, 1957.
9. Clayton, M. L., and Wier, G. J., Jr.: Experimental Data on the Healing of Ruptured Ligaments. *In* Proceedings of The American Academy of Orthopaedic Surgeons, Scientific Exhibit. J. Bone and Joint Surg., **41-A:** 1350, Oct. 1959.
10. Colonna, P. C.: Regional Orthopedic Surgery, p. 435. Philadelphia, W. B. Saunders Co., 1950.
11. Elmslie, R. C.: Recurrent Subluxation of the Ankle Joint. Ann. Surg., **100:** 364–367, 1934.
12. Frankel, E. L.: Treatment of Sprains by Injection of Procaine. Lancet, **2:** 597, 1939.
13. Hönigschmeid, Joh.: Leichenexperimente über die Zerreissungen der Bänder im Sprunggelenk mit Rücksicht auf die Enstehung der indirecten Knöchelfracturen. Deutsche Zeitschr. f. Chir., **8:** 239–260, 1877.
14. Hughes, J. R.: Sprains and Subluxation of the Ankle-joint. Proc. Roy. Soc. Med., **35:** 765–766, 1942.
15. Key, J. A., and Conwell, H. E.: The Management of Fractures, Dislocations and Sprains, pp. 1012–1020. Ed. 6. St. Louis, The C. V. Mosby Co., 1956.
16. Leonard, M. H.: Injuries of the Lateral Ligaments of the Ankle. A Clinical and Experimental Study. J. Bone and Joint Surg., **31-A:** 373–377, Apr. 1949.
17. Miltner, L. J., and Hu, C. H.: Experimental Reproduction of Joint Sprains. Proc. Soc. Exper. Biol. and Med., **30:** 883–884, 1933.
18. Miltner, L. J.; Hu, C. H.; and Fang, H. C.: Experimental Joint Sprain. A Pathologic Study. Arch. Surg., **35:** 234–240, 1937.
19. Mullins, J. F. P., and Sallis, J. G.: Recurrent Sprain of the Ankle Joint with Diastasis. J. Bone and Joint Surg., **40-B:** 270–273, May 1958.
20. O'Donoghue, D. H.: Surgical Treatment of Injuries to Ligaments of the Knee. J. Am. Med. Assn., **169:** 1423–1431, 1959.
21. Pennal, G. F.: Subluxation of the Ankle. Canadian Med. Assn. J., **49:** 92–95, 1943.
22. Robichon, J.: Management of Ankle Injuries. Canadian Serv. Med. J., **13:** 160–163, 1957.
23. Thorndike, Augustus, Jr.: Athletic Injuries. Prevention, Diagnosis and Treatment. Philadelphia, Lea and Febiger, 1938.
24. Watson-Jones, Reginald: Fractures and Joint Injuries. Vol. 2, pp. 813–831. Ed. 4. Baltimore, The Williams and Wilkins Co., 1956.
25. Whitman, Royal: A Treatise on Orthopaedic Surgery. Ed. 7. Philadelphia, Lea and Febiger, 1923.
26. Wiles, Philip: Essentials of Orthopaedics, pp. 296–297. Ed. 2. Boston, Little, Brown and Co., 1955.

A Locking Little Finger

BY ADRIAN E. FLATT, M.D., F.R.C.S., IOWA CITY, IOWA

From the Department of Orthopaedic Surgery, State University of Iowa, Iowa City

A typist, twenty-five years of age and married, reported to the out-patient clinic with the metacarpophalangeal joint of her left little finger locked in 90 degrees of flexion. She was unable to extend the joint actively; passively, however, the joint could be extended with very little force.

Repeated episodes of locking had occurred during the five years before admission and the patient reported that on each occasion a "painful snapping" occurred as the joint locked in flexion or as it was passively straightened. When the hand was examined the extrinsic and intrinsic muscles of the finger were found to be functioning normally and there was no disturbance in sensation of the digit. During passive flexion of the joint slightly increasing resistance to flexion was felt as the joint approached 85 to 90 degrees of flexion. At this point, the resistance suddenly released and a snap could be both heard and felt in the region of the joint. Coincident with the snapping the patient complained of momentary pain. Further flexion of the joint could then be obtained passively without pain. On passive extension a similar painful snap occurred at the same point in the arc of movement. Here again, slight resistance was felt during passive extension immediately prior to the snap.

FIG. 1-A

FIG. 1-B

Fig. 1-A: The position of the joint when locked.
Fig. 1-B: The metacarpal head exposed to show the flattening of the palmar and middle portions of the articular surface.

Roentgenograms showed no abnormality. A sesamoid was present in the normal position at the level of the metacarpophalangeal joint of the little finger.

Opinions as to the etiology varied: the majority of the departmental staff and I thought that this was a disturbance of the extensor mechanism at the level of the metacarpophalangeal joint. A minority of one favored a deformity of the joint surface as the cause of the locking. Operation was recommended.

Ulnar-nerve block at the elbow was done. Manipulation after anesthesia revealed no change in the physical findings previously recorded. An S-shaped skin incision was made with the central limb over the dorsum of the joint (Fig. 1-B). Since normal motor function was retained with this anesthesia the movements of the extensor tendons could be observed while the joint was locked and unlocked. No abnormality was detected in the extensor mechanism. The joint was then explored by incising the hood and capsule on the ulnar side. The contour and cartilage of the articular surface of the proximal phalanx appeared to be normal, but the shape of the head of the metacarpal was abnormal. The normal rounded contour of the joint surface between the superior and the palmar surfaces of the metacarpal head was heaped up into a ridge so that the palmar surface was flattened,

making the plane of its surface almost perpendicular to the plane of the middle third of the articular surface (Figs. 1-A, 1-B, and 2). As the joint was flexed the ridge on the metacarpal acted as an obstruction over which the base of the phalanx suddenly snapped. Once over this obstruction, the base of the phalanx came to rest on the flattened palmar joint surface where it remained locked. In extension the dorsal edge of the phalanx tended to impinge on the ridge until sufficient power was applied to force it over the ridge and into extension.

The abnormal cartilaginous ridge was skived off with a scalpel, restoring a more normal rounded contour of the metacarpal head. During this process no abnormal bone was encountered and the restoration of normal contour was accomplished simply by the removal of cartilage. Immediately after the capsule and hood were sutured together with fine catgut, the patient was able to flex and extend the joint. She returned to work fourteen days after surgery and has remained free of symptoms.

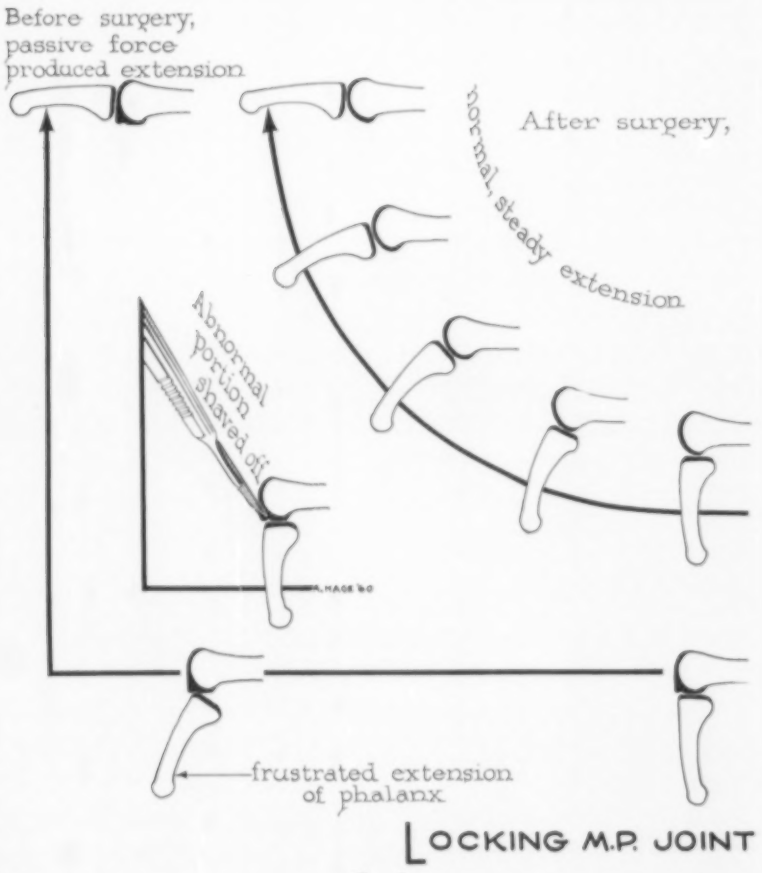


FIG. 2

This drawing has been deliberately exaggerated to show the presence of the cartilaginous ridge and the flattening of the palmar articular surface. Extension of the phalanx was frustrated until the ridge had been skived away. After this a normal steady arc of extension was possible.

DISCUSSION

In a previous report on the locking of an index finger [2] reference was made to a paper by Bizarro on the sesamoid and supernumerary bones of the limbs. In this paper he recorded the occasional presence of an abnormal palmar cornual projection on the metacarpal head when the sesamoid bone is very small or absent. In the case recorded here it is impossible to say whether the sesamoid should be

considered abnormally small, but it was of normal shape and did not appear to be grossly smaller than the other sesamoids. The abnormal palmar cornual projection that was present on the metacarpal head accounted for the locking of the joint.

In the absence of any known history of trauma to the hand it would seem reasonable to assume that the abnormal projection on the metacarpal head represented an underdeveloped second sesamoid which had migrated from the tendinous insertion into the cartilage of the metacarpal head.

REFERENCES

1. Bizarro, A.H.: On Sesamoid and Supernumerary Bones of the Limbs. J. Anat., **55**: 256–268, 1921.
2. Flatt, A.E.: Recurrent Locking of an Index Finger. J. Bone and Joint Surg., **40-A**: 1128–1130, Oct. 1958.

Male Sex Hormone and Osteo-Arthrosis in Mice*

BY RUTH SILBERBERG, M.D., AND MARTIN SILBERBERG, M.D., ST. LOUIS, MISSOURI

From the Department of Pathology, Washington University School of Medicine, St. Louis

Male mice of strains susceptible to osteo-arthrosis are usually more prone to develop the disease than females [7-10]. This sex difference might either be genetically determined or be due to differences in the action of male or female sex hormones, respectively. Orchiectomy performed in the growing male animal decreased both the incidence and the severity of degenerative joint disease [9]. These results may be related to the general delay of skeletal development and aging that are observed in the castrate or they may be the consequence of the withdrawal of a specific metabolic stimulation exerted by testicular secretions on the articular tissues. In an attempt to analyze the problem further, we studied the influence of the administration of male sex hormone on the articulations of male mice. Since these tissues are highly susceptible to hormonal influences during growth [7], it was decided to administer the hormone only during the growing period of life, from five weeks to six months of age. The findings obtained are presented herein.

MATERIAL AND METHODS

Sixty male mice of the closely inbred strain C57BL Jax6, raised in our laboratory and fed a stock diet of purina laboratory chow and water *ad libitum*, were divided into two groups, littermates being divided equally, whenever possible. Thirty animals received no treatment and served as controls. When the other thirty animals had reached an age of about five weeks and an average weight of eleven grams, they were injected subcutaneously three times weekly with 0.01 milligram of testosterone propionate ** dissolved in sesame oil. The treatment was discontinued at the age of six months. Weights were taken biweekly. All mice survived to the age of eighteen months; at this age, both the test and the control animals were sacrificed. Necropsies failed to show major lesions; in the test animals there were occasional oil cysts at the site of the injections. The femora and tibiae including the knee joints were removed from both sides, partly freed of soft tissues, fixed and decalcified in Bouin's solution, and embedded in paraffin; semiserial sections five micra thick were stained with hematoxylin and eosin. The microscopic findings in the joints were recorded and graded, as described elsewhere [9]. The statistical significance of the changes was analyzed by the chi-square method.

OBSERVATIONS

Weights

The mean weights of both the control and the test animals were similar throughout, increasing from eleven grams at the beginning of the observations to twenty-six grams at the age of six months and twenty-nine grams at the age of twelve months. Subsequently, some animals lost and a few gained weight, but the mean weights remained constant. At death there were two unusually large individual variations, one animal weighing forty-two grams and another, twenty-two grams.

* The investigation was supported by Grants A-22 (C9) and A-1679 (C2) from the National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, Public Health Service.

** We are indebted to the Schering Corporation for a generous supply of the crystalline testosterone propionate.

Figs. 1 through 6: Sections of the knee joints of male mice of strain C57BL Jax6. These animals had received injections of testosterone propionate and were sacrificed at eighteen months of age.

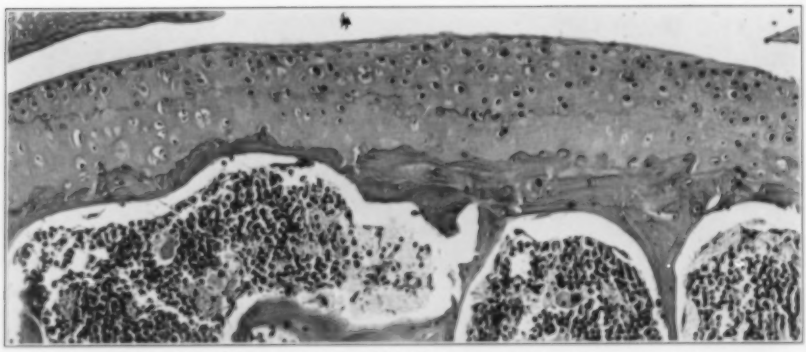


FIG. 1

Unchanged tibial surface: the cartilage cells are resting and are regularly arranged (hematoxylin and eosin, × 150).

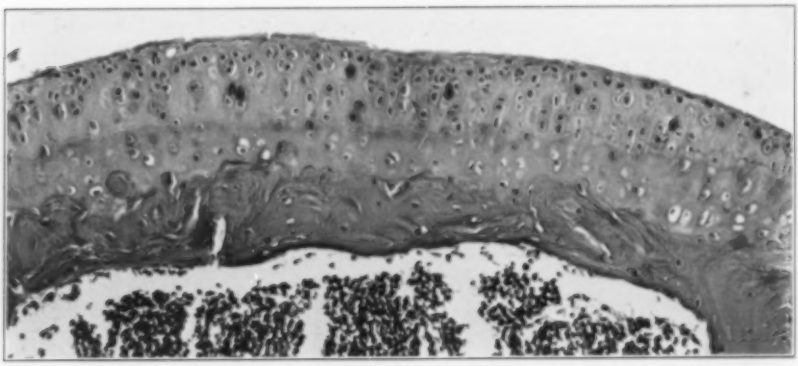


FIG. 2

Tibial surface showing hyperplasia, hypertrophy, and degeneration of cartilage cells (hematoxylin and eosin, × 150).

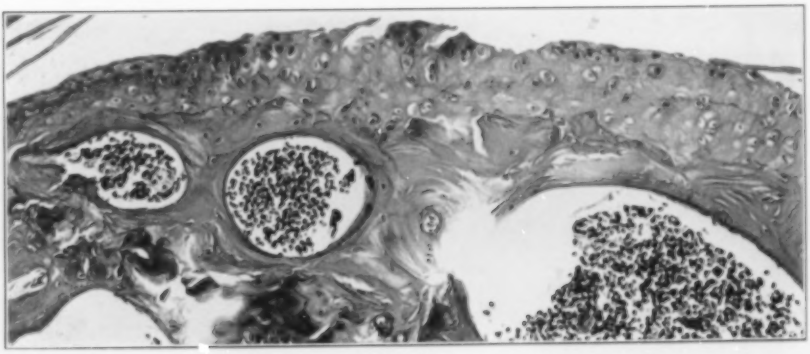


FIG. 3

Tibial surface showing advanced hypertrophy and degeneration of cartilage cells with fraying and shallow erosion of the surface (hematoxylin and eosin, × 150).

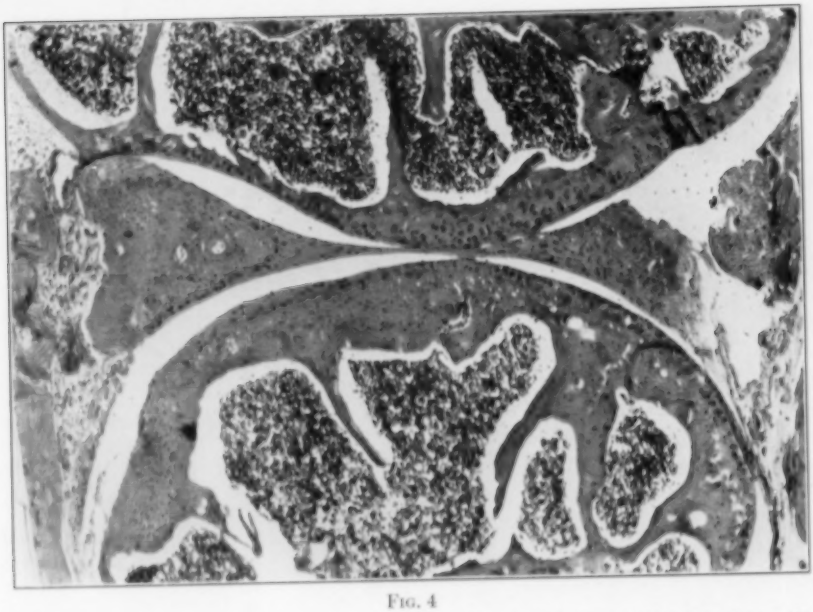


FIG. 4

General view of unchanged knee joint: the tibia at the bottom; the femur at the top; the menisci at the right and left centers (hematoxylin and eosin, × 80).

Microscopic Examination

The findings in the joints could be classified as follows: (1) unchanged; (2) old-age changes; or (3) osteo-arthritic lesions. Each animal was listed only once, even though some joints had both simple aging changes and osteo-arthrosis. Such animals were recorded as having osteo-arthrosis.

Aging changes in this study were considered to include either hyperplasia, hypertrophy and degeneration of articular cartilage, or slight proliferation of the synovial membrane in the presence of an intact surface of the cartilage. Osteo-arthrosis was considered to be present when there was a combination of growth processes and regressive changes involving the articular cartilage of the femur, tibia, or patella, singly or in combination. There might be focal or diffuse central or marginal cartilaginous or osseous outgrowths and degeneration and breakdown of cartilage cells associated with surface defects of varying depth and width. Detachment of necrotic cartilage as well as eburnation or erosion of the exposed bone, or both, were seen. The soft tissues were usually involved: mucoid swelling and chondrification or ossification of ligaments were noticeable; proliferation of the synovial membrane, fibrosis, and cyst formation in the epiphyseal-bone marrow were also common findings. This variety of changes led to distortions and deformities of the joint cavity. In some instances ulcerative changes were predominant; in others, hypertrophic lesions predominated; still others showed both types of lesion. In the test animals hypertrophic lesions outnumbered those of the ulcerative type (Figs. 1 through 6).

Results

The observations in the knee joints are summarized in Table I.

None of the animals receiving testosterone had unchanged joints, whereas six of the control mice (20 per cent) still had intact articulations. This difference is statistically significant at the 5 per cent level. Old-age changes were present in the

joints of six hormone-treated mice (20 per cent) and in the joints of sixteen mice (53 per cent) of the control series ($P < .005$). Of the test animals twenty-four (80 per cent) had osteo-arthrosis, whereas only eight (27 per cent) of the control animals were so afflicted. Thus, in the treated animals, as compared with the untreated ones, testosterone had significantly increased the incidence of osteo-arthrosis ($P < .001$). There were no significant differences in the relative incidence of severe and slight lesions found in the test and control animals.

TABLE I

FINDINGS IN THE KNEE JOINTS OF CONTROL AND TEST MICE

Series	No. of Mice	No Change (*No.*)	(*Per cent*)	Aging Changes (*No.*)	(*Per cent*)	Osteo-arthrosis (*No.*)	(*Per cent*)
Controls	30	6	20	16	53	8	27
Tests	30	0*	0	6**	20	24***	80

Statistical significance of differences: * $P < .05$
** $P < .005$
*** $P < .001$

There was no correlation between the weights of the individual animals and the presence or absence of either old-age changes in the joints or the incidence and severity of osteo-arthrosis.

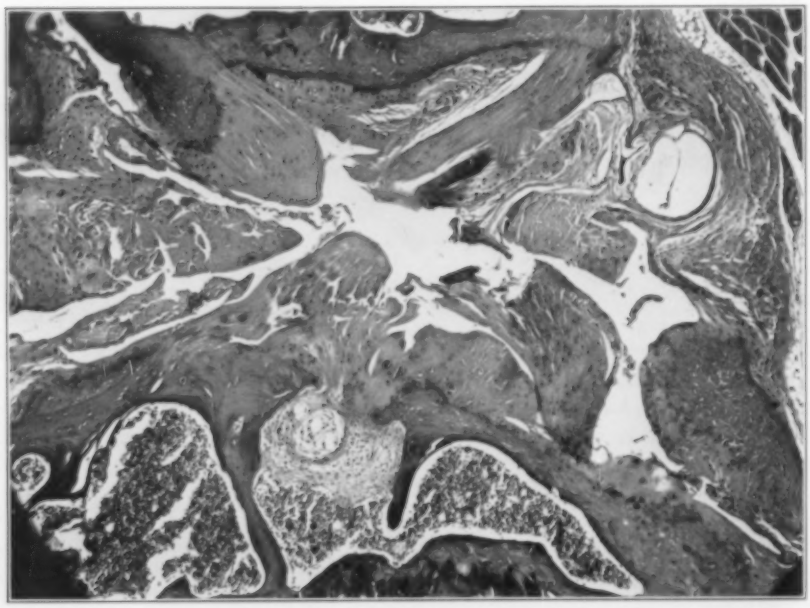


FIG. 5

General view of osteo-arthritic knee joint from the region of the intercondylar notch: cartilaginous overgrowth with fibrillation of the cartilage and fibrosis of epiphyseal bone marrow of the tibia (hematoxylin and eosin, × 80).

DISCUSSION

Old mice of strain C57BL Jax6 which had been treated with small doses of testosterone propionate during the period of growth failed to show any intact knee joints, whereas 20 per cent of the untreated controls still had unaltered joints at

FIG. 6

General view of osteo-arthritic knee joint: ulceration of the cartilage on the opposing surfaces of the tibia (bottom) and of the femur (top), with eburnation of the bone in the floor of both ulcers (hematoxylin and eosin, × 80).

the same age. The incidence of osteo-arthrosis was significantly increased in the treated animals, as compared with the controls of the same age. Aging changes, on the other hand, were numerically decreased in the test animals; however, inasmuch as these changes constitute forerunners of osteo-arthritic lesions, the decline in their incidence, together with the decrease in the number of intact joints in the test animals, does not indicate a delay of the aging process, but points to an accelerated transition from the simple changes of aging to the osteo-arthritic state. With respect to columns in Table I, the hormonal stimulation had thus produced what might be called a shift to the right. The hormone exerted no effect on the weight of the treated mice, and there was no correlation between individual weight and the type of severity of the articular lesions encountered.

The acceleration of articular aging changes and the concurrent increase in the incidence of osteo-arthrosis subsequent to the administration of testosterone constitute another instance where the two processes show a similar response to stimulation by the same agent. The present results thus provide further support for the view that old-age changes in the joints and osteo-arthrosis are related phenomena [1-9,11,12]. Irrespective of additional factors that may be involved in the pathogenesis of degenerative joint disease—hormonal, nutritional, or mechanical—the development of arthropathy may be influenced by a modification of the preceding aging changes.

The effect of testosterone on the joints is precisely the opposite of that of orchiectomy. The combination of these findings strongly suggests that the male sex hormone plays a role in the greater susceptibility of the male to osteo-arthrosis. The effect of the hormone on articular cartilage is striking and almost as pronounced as that of somatotropin, which raised the incidence of degenerative joint disease to approximately the same level as testosterone. In addition, however, somatotropin accentuated the severity of the lesions [7], an effect that was lacking

in the present experiment. This difference, however, may not be basic and may perhaps be modified by dosage and duration of the hormonal treatment. The effect of testosterone has another feature in common with that of somatotropin; namely, the production of predominantly hypertrophic joint lesions. As shown repeatedly [2,4,6,7,8], stimulation of cartilage growth and the evolution of degenerative joint disease go hand in hand. After injections of crude anterior hypophyseal extracts, somatotropin, or nortestosterone; transplantation of hypophyses; and after feeding diets enriched with lard; the development of osteo-arthrosis was promoted. The evolution of the arthropathy was retarded under conditions that inhibited growth of cartilage, such as injections of ACTH, severe caloric restriction, and castration [7,8,9]. It may be therefore concluded that the arthrosis-promoting action of testosterone is likewise related to its growth-stimulating activity. The latter, in turn, must be related to its protein-anabolic action; nortestosterone, which resembles testosterone in regard to the latter but has little if any androgenic potencies, was shown to produce articular effects similar to those exerted by testosterone [8]. The question whether the male sex hormone acts on the cartilage cells directly or through the intermediation of other phases of metabolism could not be answered by the present experiments and will require further studies.

SUMMARY

Male mice of strain C57BL Jax6 were treated with small doses of testosterone during growth and observed to the age of eighteen months. In mice thus treated, aging changes in the joints were accelerated and the incidence of osteo-arthrosis was significantly increased, as compared with conditions established in untreated mice. The results reported thus provide additional evidence for the importance of aging changes in the development of deforming arthrosis. The aging and arthrosis-promoting effects of testosterone are thought to be related to its growth-promoting effect and therefore to its protein-anabolic action. The male sex hormone thus seems to be responsible for the higher susceptibility of the male mouse to degenerative joint disease as compared with that of the female.

REFERENCES

1. Bauer, Walter, and Bennett, G.A.: Experimental and Pathological Studies in the Degenerative Type of Arthritis. J. Bone and Joint Surg., **18:** 1–18, Jan. 1936.
2. Bennett, G.A.; Waine, Hans; and Bauer, Walter: Changes in the Knee Joint at Various Ages. With Particular Reference to the Nature and Development of Degenerative Joint Disease. The Commonwealth Fund: Cambridge, Harvard University Press, 1942.
3. DePalma, A.F.: Degenerative Changes in the Sternoclavicular and Acromioclavicular Joints in Various Decades. Springfield, Illinois, Charles C. Thomas, 1957.
4. Heine, J.: Über die Arthritis deformans. Arch. Pathol. Anat., **260:** 521–663, 1926.
5. Parker, Frederic, Jr.; Keefer, C.S.; Myers, W.K.; and Irwin, R.L.: Histologic Changes in the Knee Joint with Advancing Age. Relation to Degenerative Arthritis. Arch. Pathol., **17:** 516–532, 1934.
6. Payr, Erwin: Gelenksteifen und Gelenkplastik. Tell 1: Pathologische Biologie der Gelenke. Pathogenese und Pathologische Anatomie der Ankylosen. Klinik, Diagnostik und Anzeigestellung. Berlin, Julius Springer, 1934.
7. Silberberg, Martin, and Silberberg, Ruth: The Effects of Endocrine Secretions on Articular Tissues and their Relation to Aging Processes. *In* Rheumatic Diseases. Edited by C.H. Slocumb. Philadelphia, W.B. Saunders Co., 1952.
8. Silberberg, Martin, and Silberberg, Ruth: Effect of 17-Ethyl-19 Nortestosterone on Articular Ageing and Osteoarthrosis of Orchiectomized Mice. J. Gerontol., in press.
9. Silberberg, Ruth; Thomasson, Robert; and Silberberg, Martin: Degenerative Joint Disease in Castrate Mice. II. Effect of Orchiectomy at Various Ages. Arch. Pathol., **65:** 442–444, 1958.
10. Sokoloff, Leon: Natural History of Degenerative Joint Disease in Small Laboratory Animals. I. Pathologic Anatomy of Degenerative Joint Disease in Mice. Arch. Pathol., **62:** 118–128, 1956.
11. Weichselbaum, A.: Die senilen Veränderungen der Gelenke und deren Zusammenhang mit der Arthritis deformans. Sitzungsb. d. k. Akad. d. Wissensch., Wien, **75:** 193–243, 1877.
12. Willis, T.A.: The Age Factor in Hypertrophic Arthritis. J. Bone and Joint Surg., **6:** 316–325, Apr. 1924.

Legg-Calvé-Perthes Disease—Factors in Healing

BY E. L. RALSTON, M.D., PHILADELPHIA, PENNSYLVANIA

Legg-Calvé-Perthes disease is recognized and treatment is instituted much more promptly today than twenty-five years ago. It is now not unusual to see the first roentgenographic changes appear only after a child has been under observation and treatment for some time. It may well be that in some children who are believed to have this disease the usual roentgenographic changes never develop because the clinical findings lead to early treatment, thus precluding the appearance of any of the typical roentgenographic findings.

Many of the current concepts of this disease are based on earlier studies which included children seen for the first time in rather advanced stages of the malady. It would seem that a review of patients seen early in the disease process and followed through all stages might alter some of the previous impressions. During the ten-year period of 1947 to 1957, 107 patients with Legg-Calvé-Perthes disease were seen and their treatment completed at the Children's Seashore House in Atlantic City, New Jersey. Only forty-nine of this entire group were seen and treatment started within three months of onset of symptoms. Of these, six patients had bilateral involvement and in each child treatment was instituted within three months of onset of the disease in the second hip, but not so early as this in the hip with the prior involvement. These six patients were excluded from this study because with both hips involved there was no normal hip available for comparison and the comprehensive quotient could not be determined satisfactorily. Thus, of 107 patients seen and treated during this ten-year period, forty-three children (thirty-one boys and twelve girls) had unilateral disease which was recognized within three months of onset and treated by a standard method throughout the process of the disease. According to this method of treatment all patients were put to bed with Buck's extension on the involved extremity, using four to six pounds of weight. When all spasm of the muscles about the hip had subsided, traction was continued; but daily exercises were started in which all joints of the involved extremity were put through a full range of motion. When roentgenograms revealed beginning replacement of the necrotic bone in the femoral head, a program of progressive resistance exercises was started, first with exercises in the pool and then with graduated resistance exercises on a table. After each exercise period the patient was returned to traction. This intermittent traction was continued until the roentgenograms demonstrated the criteria of healing to be described. The patient was then allowed to walk.

It was assumed at the onset that since all of these patients were seen early and treated similarly that some similarity in the clinical and roentgenographic characteristics of the disease might be found. A review of these features showed the same variations that have previously been well recognized. The most striking variations were: (1) the age of the patient at the onset of the disease; (2) the amount of the involvement of the capital epiphysis; (3) the duration of the disease process; and (4) the final comprehensive quotient.

VARIATIONS

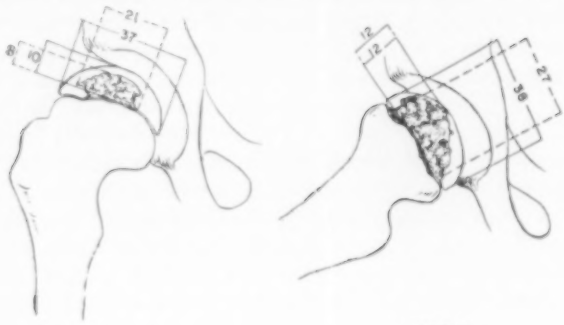
The Age of the Patient at Onset of the Disease

It is frequently difficult to determine the exact date of onset of the disease. Ståhl pointed out that most authors designated the date of the first examination

FIG. 1-A

FIG. 1-B

Anteroposterior and lateral roentgenograms made eighteen months after onset of Legg-Calvé-Perthes disease in a seven-year-old boy. This is the only patient designated as showing complete involvement of the capital epiphysis. It is apparent that a number of small areas may show some preservation or may represent some reossification.



AP

Epiphyseal height - 10 mm.
Epiphyseal width - 37 mm.
Defect height — 8 mm.
Defect width — 21 mm.

$$\text{AP \% Involved } \frac{21 \times 8}{37 \times 10} = 45\%$$

% Involved

$$\frac{\text{Lat. \%} + \text{AP \%}}{2}$$

$$\frac{71 + 45}{2} = 58\%$$

LATERAL

Epiphyseal height - 12 mm
Epiphyseal width - 38 mm.
Defect height — 12 mm.
Defect width — 27 mm.

$$\text{Lat. \% Involve } \frac{27 \times 12}{38 \times 12} = 71\%$$

FIG. 2

as the onset. The time of the first examination, however, varies so greatly and is influenced by so many factors that it is entirely unsatisfactory. Ståhl attempted to date the onset on the basis of the changes seen in the first series of roentgenograms. Cases with early changes, including more or less pronounced sclerosis of the epiphysis, were considered to be at least three months old. If conspicuous fragmentation was manifested, the onset was believed to have occurred nine months earlier, whereas if the healing process had already begun at the time of the first examination, the pathological process was assumed to have existed at least eighteen months. When I attempted to apply Ståhl's method to the group of cases reported here, I found it unsatisfactory. The total duration of the disease process varied so widely (from eight to fifty-nine months) that the appearance of the femoral head on the roentgenogram was not a reliable indication of the time since onset.

FIG. 3-A

FIG. 3-B

Anteroposterior and lateral roentgenograms made twenty-six months after onset of Legg-Calvé-Perthes disease in a boy, eight years and eight months of age. The defect in the subchondral bone is still visible, and there is a central defect in about 25 per cent of the epiphysis (lateral view).

FIG. 3-C

FIG. 3-D

Six weeks later, there is a well defined layer of subchondral bone, and the central defect is less than 25 per cent (lateral view).

Occasionally, roentgenograms of the abdomen, obtained for unrelated reasons, demonstrate well advanced roentgenographic changes of Legg-Calvé-Perthes disease in children who have had no pain whatsoever in the hip or lower extremity and no noticeable limp. Physical examination of these children demonstrates the characteristic limitation of motion to be expected from the appearance of the hip on the roentgenogram. In such cases, it is, of course, impossible to establish the date of onset of the disease.

Conversely, a child may have a slight limp and physical examination may reveal some spasm and restriction of motion, yet nothing abnormal appears on roentgenograms obtained either at that time or six weeks later. Some months later, after the clinical findings have disappeared and the child has resumed normal activity, symptoms recur and early roentgenographic changes are now apparent. In these cases I believe that the original symptoms and physical findings indicated the onset of the disease even though roentgenographic manifestations may have been delayed. I also believe that in certain cases these early symptoms and findings may be manifestations of a reversible stage of the disease and that if proper protection from weight-bearing is maintained for a sufficient length of time, the progressive changes typical of Legg-Calvé-Perthes disease may be completely averted. In all of the patients reported here the date of onset of the disease was

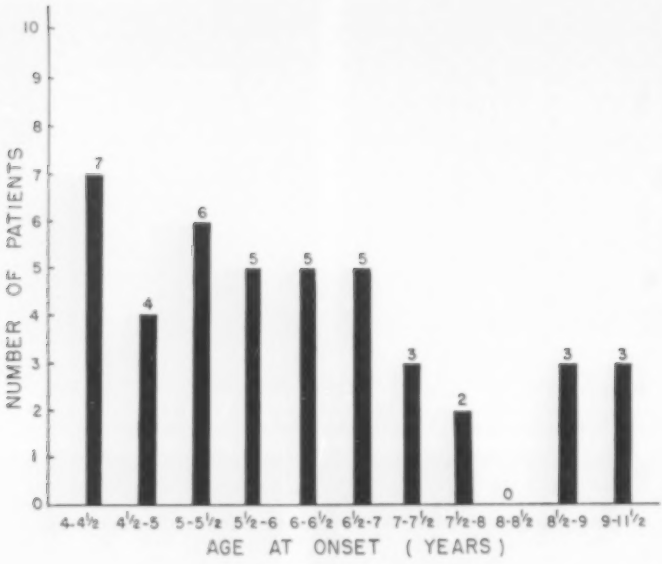


CHART I

assumed to be the date on which the child first complained of pain or a limp was first noted. Roentgenograms of the involved hip made either at that time or at a later date showed, in all cases, findings consistent with the early changes of the disease.

The chronological age of the patients in this series at the onset of the disease varied from four to eleven and one-half years. The skeletal age, as determined from roentgenograms of the hand and wrist, showed just as much variation.

It has been recognized for some time that patients with this disease show retardation of their skeletal age [3]. The retardation of the skeletal ages of the patients in this series is now being investigated and will be reported. The approximate average retardation observed at the time of writing was one year and nine months.

The Percentage of Involvement of the Capital Epiphysis

Although it has been frequently pointed out that the femoral head may not be completely involved in the process of necrosis, this aspect of the disease has not received sufficient emphasis. Jonsäter, who has given us the best description of the histological changes in this disease, mentioned that only "here and there" he saw remnants of bone that were still viable. All of his punch biopsy specimens were taken from the superior portion of the femoral head and not from the posterior-inferior portion, where there is usually some preservation of normal bone architecture. Preservation of a portion of the capital epiphysis is usually recognized only when lateral roentgenograms of the head and neck are obtained together with the anteroposterior views at frequent, regular intervals throughout the course of the disease. In our group of forty-three patients, only one showed complete involvement of the epiphysis, as evidenced by total (100 per cent) fragmentation (Figs. 1-A and 1-B). All of the others showed varying amounts of preservation of the normal architecture.

Since varying amounts of the capital epiphysis may be involved in this disease, it would seem desirable to have some method of measuring the involvement

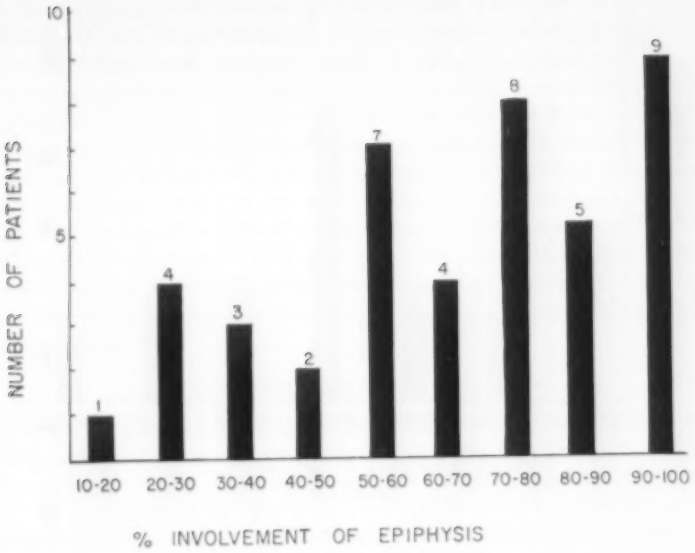


CHART II

quantitatively. The method used in all cases is illustrated in Figure 2. The measurements taken were the greatest height and width of the epiphysis and the greatest height and width of the portion of the epiphysis involved in the process of fragmentation, as seen on both the anteroposterior and lateral roentgenograms. Review of serial roentgenograms indicated that some areas of the epiphysis may show increased bone density early in the disease process and yet later never develop fragmentation. In this study the involved portion is considered to be only that part that undergoes fragmentation. This gives a true picture of the extent of actual bone necrosis. Although this method gives only a rough approximation of the amount of the epiphysis involved in the disease, it is of interest that the variation in the maximum percentage of involvement in the patients in this study ranged from 8 to 100 per cent (Chart II).

The Length of the Disease Process

I have already discussed the difficulties encountered in determining the exact

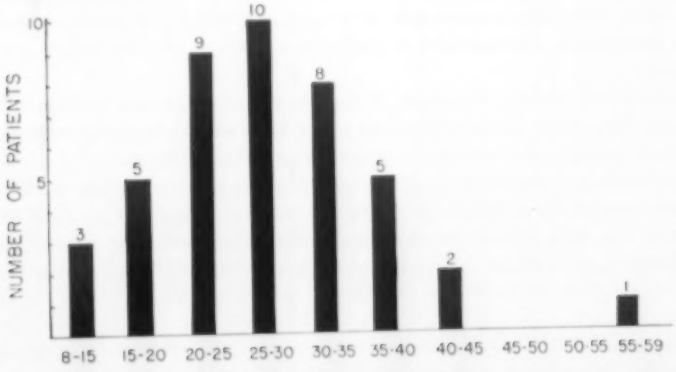


CHART III

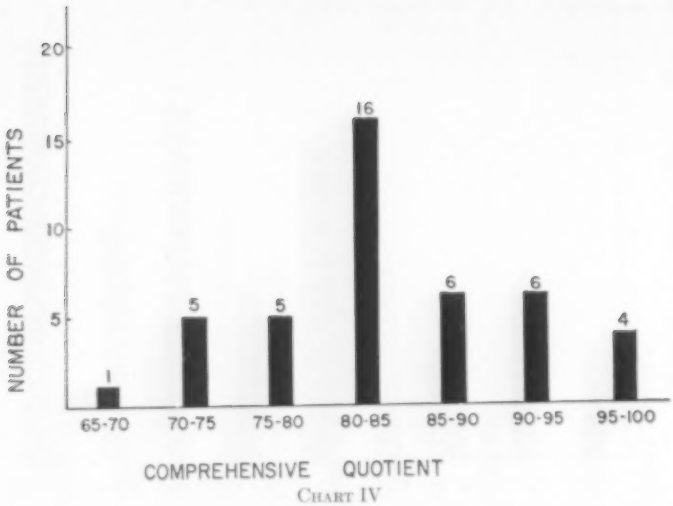


CHART IV

date of onset of the disease. The exact date of termination of the disease can be just as difficult to establish. Ståhl defined the end point of the disease in his group of patients as the time when roentgenograms showed that substantially normal bone had been re-formed in the capital epiphysis. I found that this definition does not give a sharp end point, and that with different observers the time selected as the end point may vary by as much as six to twelve months. All of the patients in this study who were followed until closure of the epiphyseal plate showed continuing remodeling changes in the head and neck up to the time of closure, so that cessation of the remodeling process is not a good end point. Furthermore, it is sometimes difficult to determine when a narrowing central defect in the head is completely replaced by normal-appearing bone. The end point that I have used is now defined as: replacement by new bone in the capital epiphysis to the extent that a complete, well defined subchondral layer of bone is visible on both the anteroposterior and the lateral roentgenograms and any defect remaining in the epiphysis does not constitute more than 25 per cent of the epiphysis on either the anteroposterior or lateral roentgenograms. This has also been the point at which unsupported weight-bearing is permitted (Figs. 3-A through 3-D). Changes do take place after this end point has been reached, but use of this standard has enabled me to determine a more precise and standardized end point and has been useful in the clinical management of patients, as well as in a statistical review of the problem.

As previously stated, the onset of the disease in this series has been defined as the date when pain or limp was first noted in a child whose hip subsequently showed roentgenographic changes characteristic of the disease.

Using these end points defined, the length of the disease process in this group of patients varied from eight to fifty-nine months (Chart III). This extreme variation in the duration of the disease process differs from the figures that are usually given, most authors listing the variation as from two and one-half to four years.

The Final Comprehensive Quotient

Heyman and Herndon presented a very useful method of measuring the anatomical end result in Legg-Calvé-Perthes disease. The figures reported for the

cases in the present series represent the comprehensive quotient at the end point of the disease (Chart IV) although, as I have already pointed out, there may be some further change for several years, until the epiphyseal plate closes.

It was in connection with these four features that the most striking variations in this group of forty-three patients occurred. The extent of these variations emphasizes that there is no standard textbook description of this disease. Once these variations had been defined, the next logical step was to correlate them. Can one of these variations be related to one or all of the others, or may one variation be the cause of one or all of the others? Certain attempts have been made in the past to correlate these variables [1,2,7]. Thus, it has been frequently assumed that the younger the patient, the more quickly the disease process will run its course. It has been likewise stated that the younger the patient, the better will be the anatomical end result.

STATISTICAL SIGNIFICANCE OF VARIATIONS

Statistical methods are available to determine whether one variable is related to another. The method most appropriate to the present study is the rank coefficient of correlation [6]. This coefficient denotes the correlation or lack of correlation between two sets of variable figures. It is determined by the formula, r equals $1-\frac{6\,\Sigma d^2}{N(N^2-1)}$ where Σd^2 represents the sum of the squares of the differences in the two variables being analyzed and N represents the number of patients in the group being analyzed. If there is complete correlation between the two groups of figures according to rank, the coefficient will be +1. If there is no correspondence between the two sets of figures, the coefficient will be 0. If the correlation is of a negative nature and absolutely true, then the coefficient will be −1. Thus, in any of these groups of variables, the rank coefficient of correlation may fall at any point between +1 and −1. The closer to the extremes, the more significant the relationship; the closer to 0, the less significant the relationship. For example, if we were to rank subjects A,B, and C in order of their age at onset of the disease, we might find the ranking:

1. A
2. B
3. C

If we then attempted to rank them according to the length of the disease process, we might find the ranking:

1. A
2. B
3. C

If this were true, then the value for r would be +1. However, if the ranking for the length of the disease process were:

1. C
2. B
3. A

then r would be −1. If there were no correlation according to rank, then r would be 0.

The age at onset of the disease and duration of the disease process: It has been frequently asserted that the younger the child, the more quickly will the disease run its course. When the age at onset was plotted against the duration of the dis-

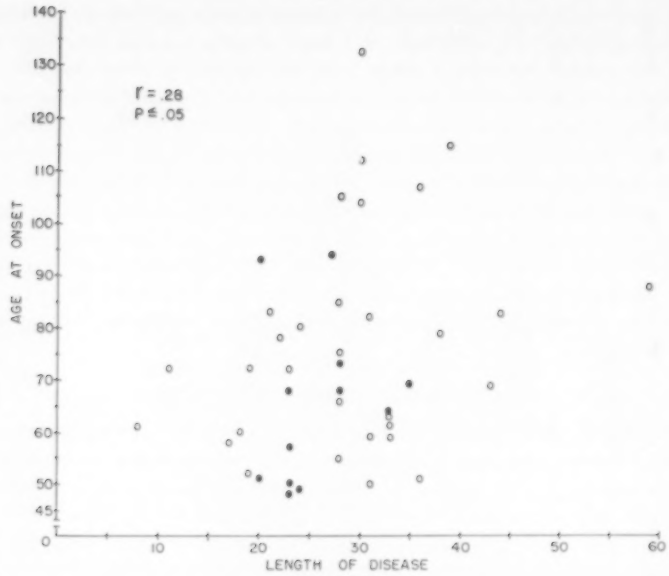


CHART V

ease, the resultant graph was not a straight line (Chart V); furthermore, the rank correlation coefficient was 0.28. Thus, statistically, the relationship between the age at the onset of the disease and its duration is not nearly so close as some authors have assumed [1,2,7].

Comprehensive quotient and age at the onset of the disease: It has also been frequently stated that not only is the disease process likely to run a faster course, but

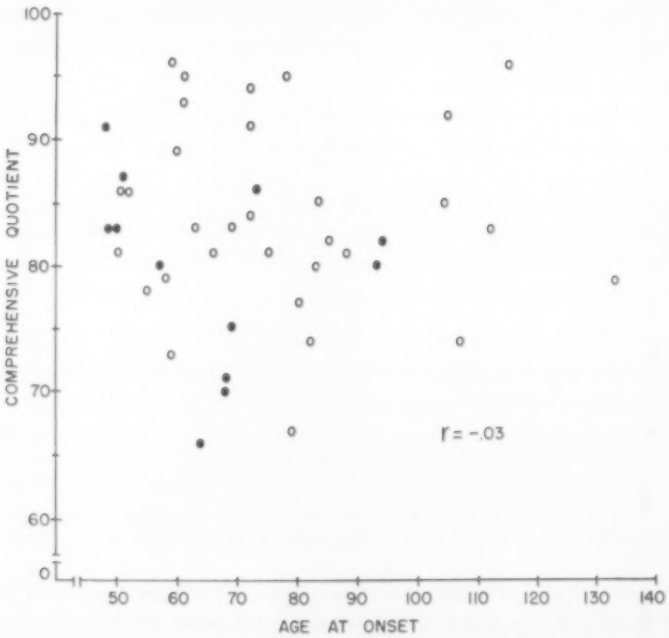


CHART VI

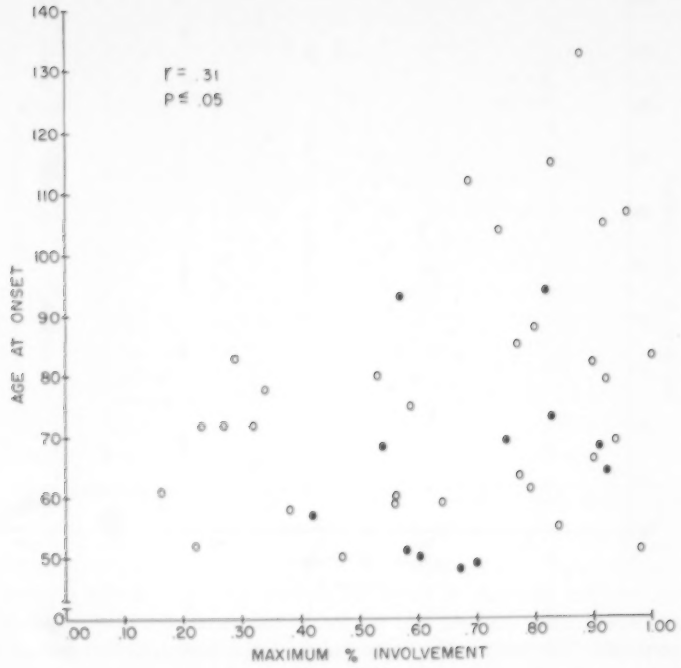


CHART VII

the anatomical end result is better when the disease occurs in the younger child. Analysis of the data on the comprehensive quotient and the age at onset of the disease in the patients reported here showed a coefficient of correlation of −0.03 (Chart VI). This result, of course, indicates that there is no correlation between these two features of the disease in these cases.

Age at onset of the disease and maximum percentage of involvement of the capital epiphysis: Studies by Trueta demonstrated variations in the blood supply of the capital epiphysis in different age groups. These observations suggest that there may be some relationship between the age at the onset of this disease and the percentage of involvement of the capital epiphysis. Analysis of the data on the age at onset and the degree of involvement of the capital epiphysis in our cases showed the coefficient of correlation to be 0.31 (Chart VII). Statistically, this suggests that there may be some relationship between the age at onset of the disease and the amount of the epiphysis involved. However, this correlation coefficient indicates that these factors are not closely related.

Maximum percentage of involvement of the capital epiphysis and duration of the disease process: Of the four variables analyzed in the series reported here, these two showed the closest correlation; the coefficient was 0.72 (Chart VIII). This definitely indicates that the percentage of involvement of the capital epiphysis is related to the duration of the disease process. Since the maximum involvement of the epiphysis can be determined well before the end point of the disease is reached, this determination is useful in prognosis. One of the questions most frequently asked by parents concerning this disease is: "How long will the disease last?" Once the maximum involvement of the capital epiphysis has been determined, there is some indication of how long the disease will last, or at least how long it may take to reach the end point selected for this study (Chart VIII).

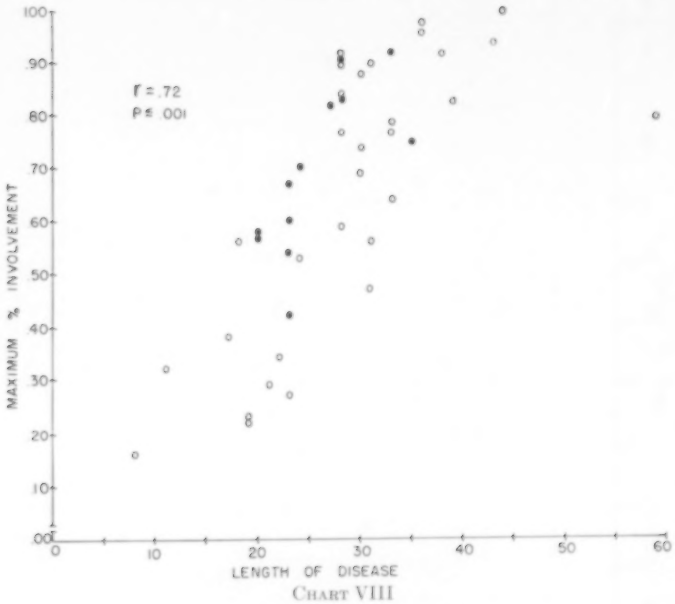


CHART VIII

The comprehensive quotient and the maximum percentage of involvement of the capital epiphysis: The relationship between these two variables is expressed by the rank coefficient of −0.40 (Chart IX). This figure indicates rather weakly that the greater the percentage of involvement of the epiphysis, the lower the comprehensive quotient; or, the lower the percentage of involvement of the epiphysis, the

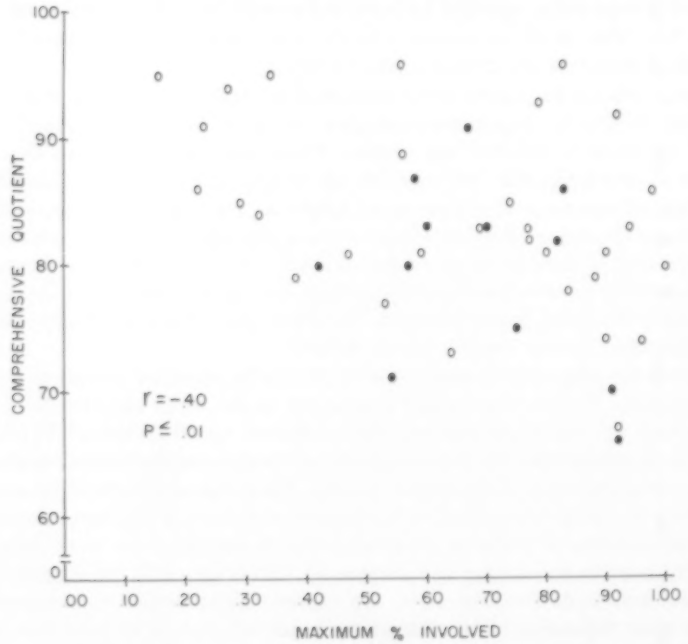


CHART IX

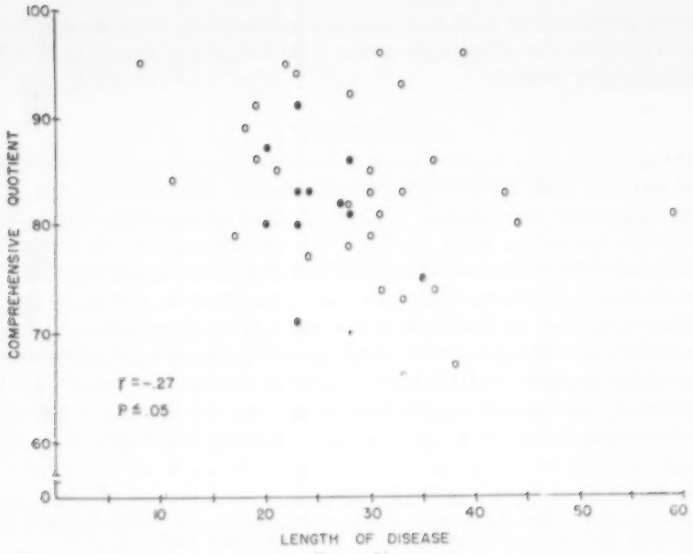


CHART X

more normal will be the final anatomical result in patients who are treated by similar, standardized methods.

The comprehensive quotient and the duration of the disease process: The relationship between these variables gave a rank correlation coefficient of −0.27 (Chart X). This is a weaker correlation than the preceding one but it indicates that there may be a tendency for the shorter disease process to end with a better anatomical result or, stated in another way, the longer it takes for the disease to come to an end, the more likely is the patient to have a poor result.

DISCUSSION

In a statistical review such as this, forty-three patients would hardly seem a sufficient number on which to base any conclusions. However, all forty-three patients were followed under well controlled and standardized methods of treatment throughout the course of the disease. The only difference within the group was the sex of the patient, the distribution being thirty-one boys and twelve girls. In a larger series it would seem better to eliminate this variable and subject each sex group to separate analysis. In this small group, however, it seemed better to analyze the two sexes as one unit. It is realized that the relationships indicated in this study may be modified by study of a larger group that, I hope, will be available in the future. The results of this study do not warrant final conclusions; rather, it should be considered as an attempt to analyze statistically certain clinical impressions concerning this disease. The results are admittedly somewhat crude.

The question of what is the best treatment for Legg-Calvé-Perthes disease has caused considerable discussion in the past. The treatment recommended has ranged from complete protection from weight-bearing during the course of the disease to complete weight-bearing throughout its process. Some advocated restricted weight-bearing during a certain short period of the disease. Surgery has also had its advocates. It is not the purpose of this paper to enter this controversy but only to indicate that clinical impressions of an end result are not acceptable in advocating a certain method of treatment. It is only by careful analysis of the end result

in groups of patients who have had standardized methods of treatment that it is possible to compare the advantages or the disadvantages of one method of treatment with those of another.

SUMMARY

An analysis has been made of some of the most obvious variable features in a group of patients with Legg-Calvé-Perthes disease, all seen early and treated similarly. This study was initiated with the thought that perhaps the variations in this disease are not so great as they were once thought to be, especially in groups of patients that are better standardized than those in previous studies. In the cases studied it was found that wide variations did exist, and an attempt was made to correlate these variables. However, the only strong correlation found was between the amount of involvement of the capital epiphysis and the length of the disease process. Analysis of other relationships of various features of the disease suggested some, but not a strong, correlation between any of them. It would seem that further investigation of a larger group of patients might give more definite results.

NOTE: The author gratefully acknowledges the assistance of George Moed, Ph.D., and Byron W. Wight, M.A., of the research staff of the Children's Seashore House. Their work in the preparation of statistics was supported in part by a grant from the Ford Foundation.

REFERENCES

1. BURROWS, H.J.: Coxa Plana. With Special Reference to Its Pathology and Kinship. British J. Surg., **29:** 23–36, 1941.
2. EYRE-BROOK, A.L.: Osteochondritis Deformans Coxae Juveniles or Perthes' Disease: The Results of Treatment by Traction in Recumbency. British J. Surg., **24:** 166–182, 1936.
3. GOFF, C.W.; SHUTKIN, N.M.; and HERSEY, M.R.: Legg-Calvé-Perthes Syndrome and Related Osteochondroses of Youth, pp. 82–118. Springfield, Illinois, Charles C. Thomas, 1954.
4. HEYMAN, C.H., and HERNDON, C.H.: Legg-Perthes Disease. A Method for the Measurement of the Roentgenographic Result. J. Bone and Joint Surg., **32-A:** 767–778, Oct. 1950.
5. JONSÄTER, STIG: Coxa Plana. A Histo-Pathologic and Arthrographic Study. Acta Orthop. Scandinavica, Supplementum 12, 1953.
6. MCNEMAR, Quinn: Psychological Statistics. New York, John Wiley and Sons, Inc., 1949.
7. STAHL, FOLKE: Early Coxa Plana. Age Studies. Acta Orthop. Scandinavica, **17:** 180–188, 1948.
8. TRUETA, JOSEPH: La etiología de la enfermedad de Perthes. Rev. Fac. Med., Bogotá, **24:** 743–751, 1956.
9. TRUETA, JOSEPH: The Normal Vascular Anatomy of the Human Femoral Head during Growth. J. Bone and Joint Surg., **39-B:** 358–394, May 1957.

Legg-Calvé-Perthes Disease—Pathogenesis and Evolution

Failure of Treatment with L-Triiodothyronine

By Ignacio V. Ponseti, M.D., and Ralph L. Cotton, M.D., Iowa City, Iowa

From the Department of Orthopaedic Surgery, State University of Iowa, Iowa City

In 1956, one of us (I.V.P.) reported the observations on biopsy specimens of the femoral head and neck of two patients with Legg-Calvé-Perthes disease [12]. The bone of the femoral head was necrotic and the epiphyseal-plate cartilage was fibrillated and cracked. It was surmised that loss of the blood supply to the femoral head resulted from the interruption of the retinacular vessels when they crossed the cartilage at the edge of the disrupted epiphyseal plate. Our concept of the pathogenesis of Legg-Calvé-Perthes disease is schematically represented in Figure 1. The epiphyseal-plate lesion in the two patients studied [12] was similar to the epiphyseal-plate lesion observed in rats and rabbits fed diets containing aminonitriles [11]. In 1957, it was found that low doses of l-triiodothyronine suppressed the mild forms of aminoacetonitrile poisoning in rats, whereas extremely high doses of thyroxine were necessary to accomplish the same result [13,14]. On the basis of the prevention of aminoacetonitrile lesions in rats, l-triiodothyronine was estimated to be over fifty times more active than thyroxine. Based on this experimental work, it was thought possible that l-triiodothyronine may correct the epiphyseal-plate lesion responsible for the interruption of blood supply to the femoral head in children with Legg-Calvé-Perthes disease. Faster revascularization of the necrotic femoral head could be expected if the epiphyseal plate were restored to normal by l-triiodothyronine. Our evaluation of the effects of this compound in the reconstruction of the femoral head in twenty-two children with Legg-Calvé-Perthes disease treated with the highest tolerance dose of l-triiodothyronine for from six to eighteen months is presented here.

To evaluate our results forty-four children of the same age and sex with similar involvement of the hip were paired. One member of each pair was treated with and one without l-triiodothyronine. Orthopaedic treatment, such as traction, plaster-cast immobilization, abduction brace, or a sling with crutches, was used according to the severity of the disease in both groups of patients and was similar in the paired cases.

Unfortunately, in our series, the hip was not symptomatic unless some collapse of the necrotic femoral head had occurred. Therefore, it was not possible to test the effectiveness of l-triiodothyronine in the prevention of the femoral-head necrosis, with the exception of one child with bilateral disease with initial unilateral involvement. The patients treated with l-triiodothyronine have been followed now for from two to four years. The length of follow-up is not sufficient in any of these patients to evaluate the effect of l-triiodothyronine on the end result, as represented by the final shape of the femoral head observed on the roentgenograms. Rather, we have been interested in observing whether l-triiodothyronine increases the speed of reconstruction of the femoral head in Legg-Calvé-Perthes disease. To determine this and to pair properly the patients treated with and without l-triiodothyronine it was necessary to know the early roentgenographic changes and the patterns of evolution of this disease.

MATERIAL

Sixty-one patients with unilateral Legg-Calvé-Perthes disease and five patients with bilateral involvement (fifty-four boys and twelve girls) treated at the State University of Iowa for a minimum period of two years were studied. A limp or slight pain, or both, were the presenting symptoms. Some limitation of hip motion, particularly of rotation, and muscle spasm were common clinical signs. Hip flexion and adduction contractures were observed in the severe cases. The patients had symptoms for an average of three months before coming to the clinic for treatment. Twenty-two patients (two with bilateral hip involvement) were

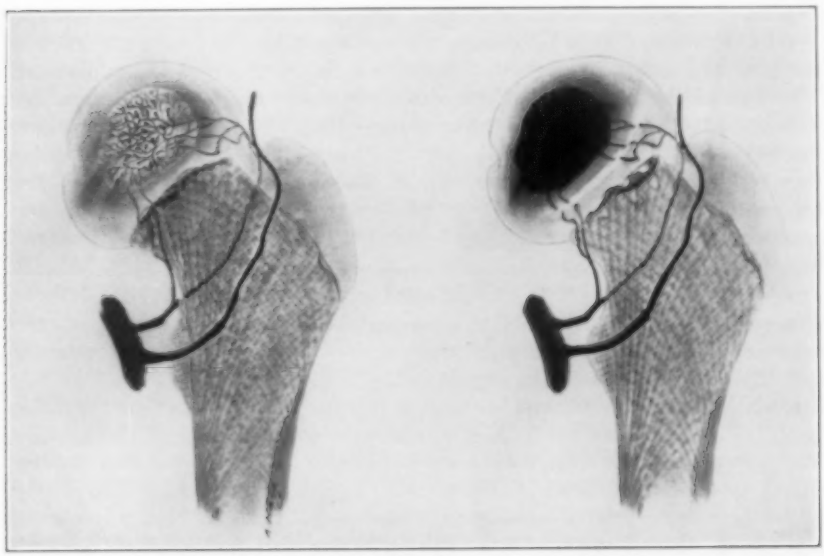


FIG. 1

Schematic representation of the blood supply to the femoral head in a child: left, normal blood supply; right, the blood supply has been interrupted at the epiphyseal plate and the femoral head is necrotic.

treated with l-triiodothyronine, and forty-four patients (three with bilateral hip involvement) were treated without the compound. Fifty micrograms per day of l-triiodothyronine was given to children up to six years of age and seventy-five micrograms per day to children over this age. The period of treatment with this drug lasted from six to eighteen months. Roentgenograms of the wrist and hand for bone-age determination were obtained in these patients both at the beginning and the end of treatment with l-triiodothyronine. The protein-bound iodine and the uptake of radioactive iodine by the thyroid gland were studied before treatment in twenty of the twenty-two patients treated with l-triiodothyronine.

Anteroposterior roentgenograms of the pelvis with the lower extremities in neutral and in Lauenstein's position were obtained every three months. An attempt was made to assess, from the serial roentgenograms, the extensiveness of the necrotic bone and the speed of its replacement by new bone. Histological studies of the entire femoral head of patients with Legg-Calvé-Perthes disease are not available; thus, the interpretation of the roentgenographic changes in density in the femoral heads of the children in this series had to be based on studies of available biopsy specimens from three cases of Legg-Calvé-Perthes disease and on studies of the similar changes observed in necrotic femoral heads obtained from adults.

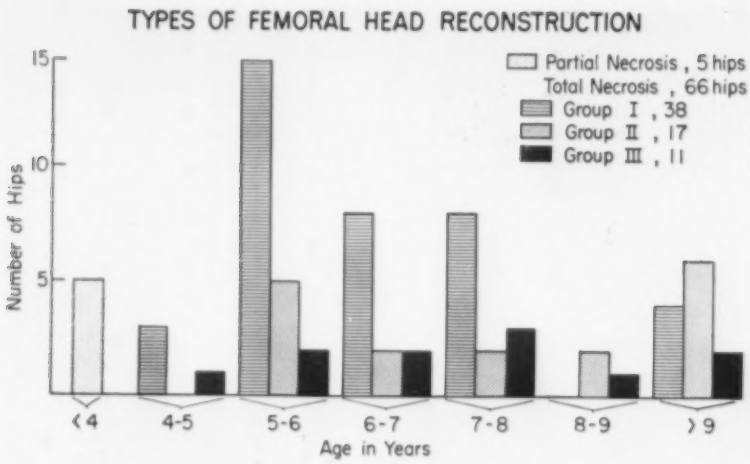


CHART I

Age incidence of the patients with different types of reossification of the femoral head.

Necrotic bone appears denser on roentgenograms. For the most part this apparent increase in density is relative, the result of atrophy of the surrounding living bone. (The necrotic bone in the femoral head will stand out clearly on the roentgenogram after several weeks of immobilization in a hip spica cast, for example.) With revascularization, the dead bone is replaced by living bone, either by the process of creeping substitution or by absorption of the necrotic bone by an advancing front of connective tissue. Both processes are often intermingled. Direct creeping substitution is prevalent in the necrotic areas that are structurally well preserved, whereas abundant fibrous tissue is commonly observed adjacent to collapsed necrotic bone. On roentgenograms, structurally well preserved dead bone is characterized by only slightly increased density. This density increases during the process of replacement by creeping substitution as new bone is laid down on the dead-bone trabeculae. When collapse occurs, the collapsed areas appear on the roentgenogram as blotchy areas of increased density intermingled

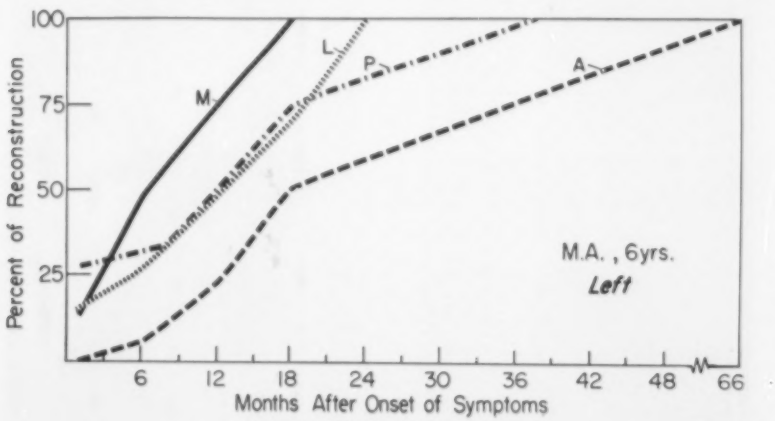


CHART II

The speed of reossification of the medial (*M*) and lateral (*L*) halves of the femoral head, as seen in anteroposterior roentgenograms, and of the anterior (*A*) and posterior (*P*) halves, as seen in lateral views.

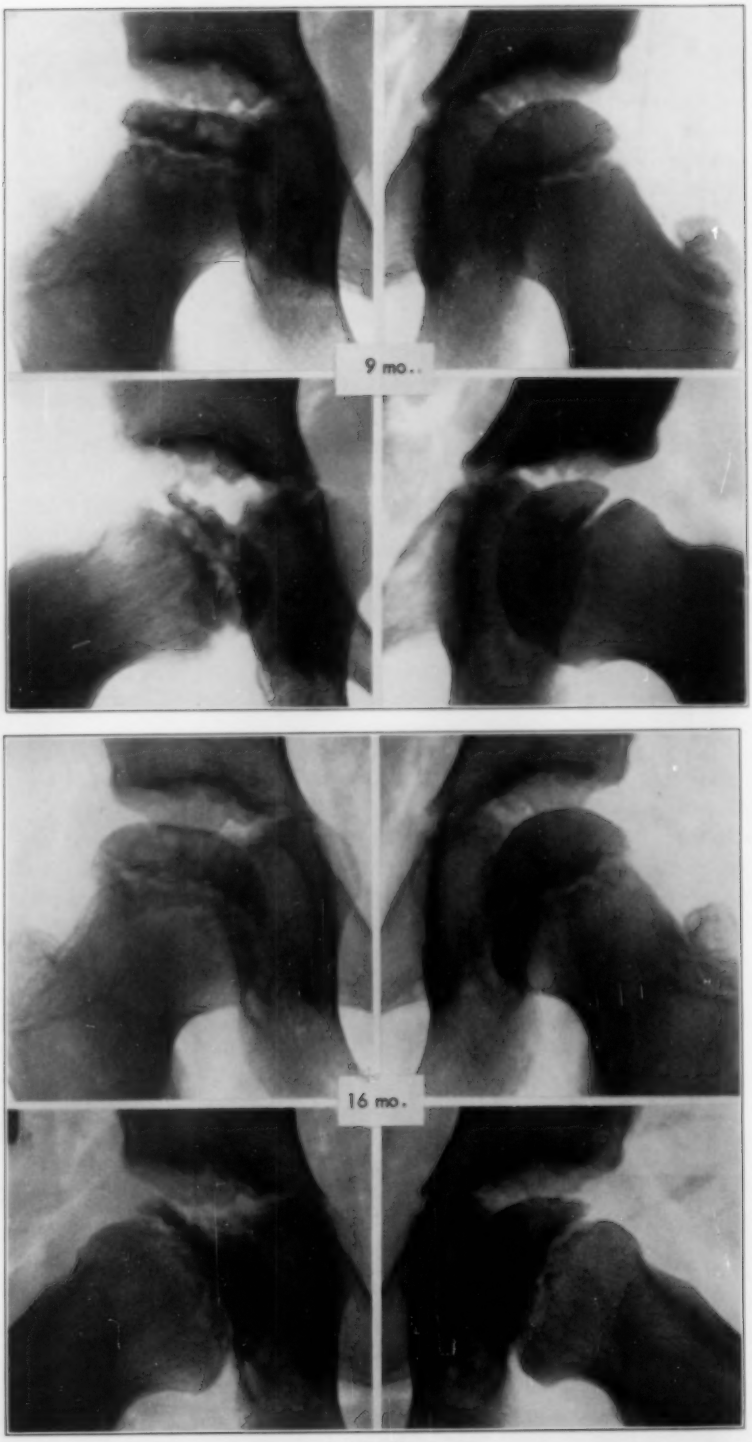


FIG. 2

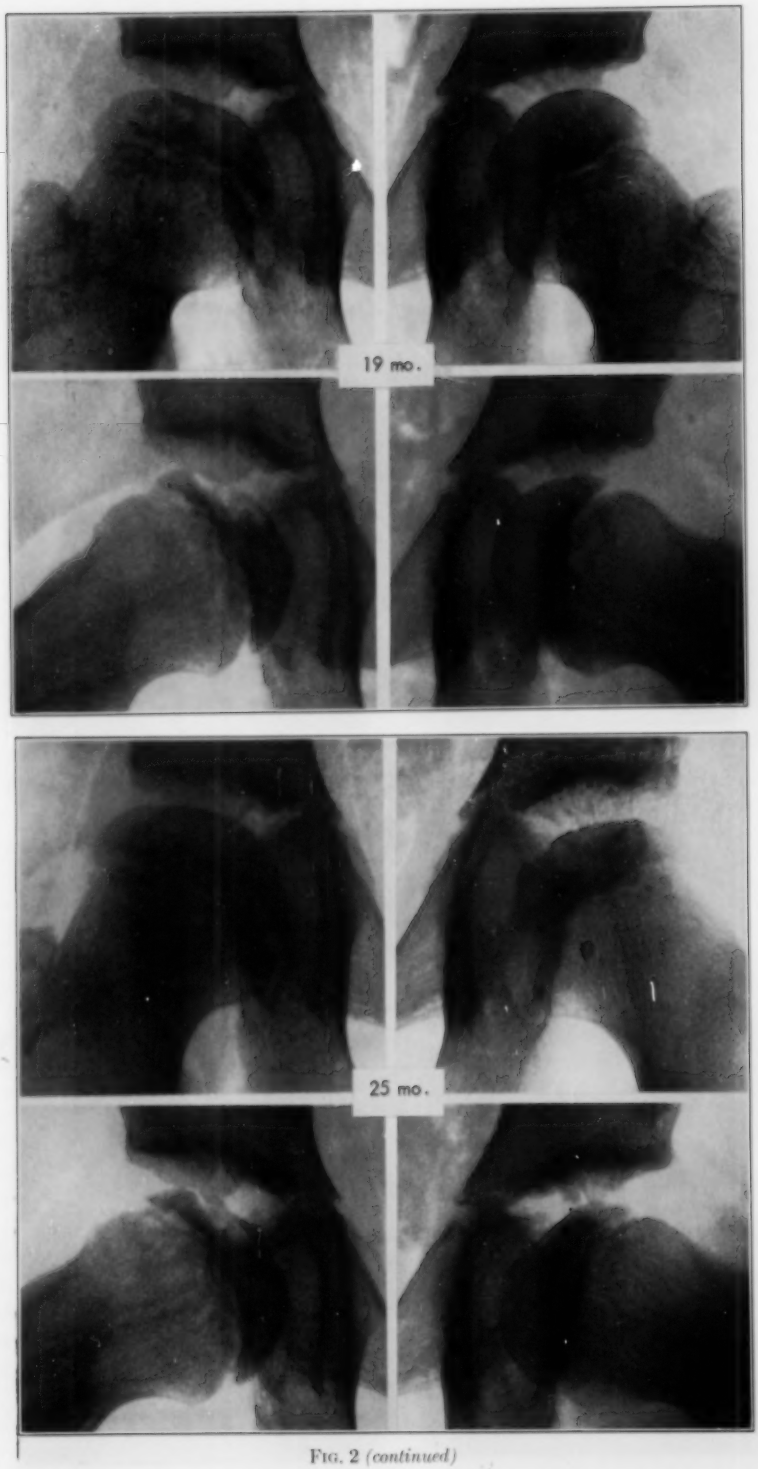


FIG. 2 *(continued)*

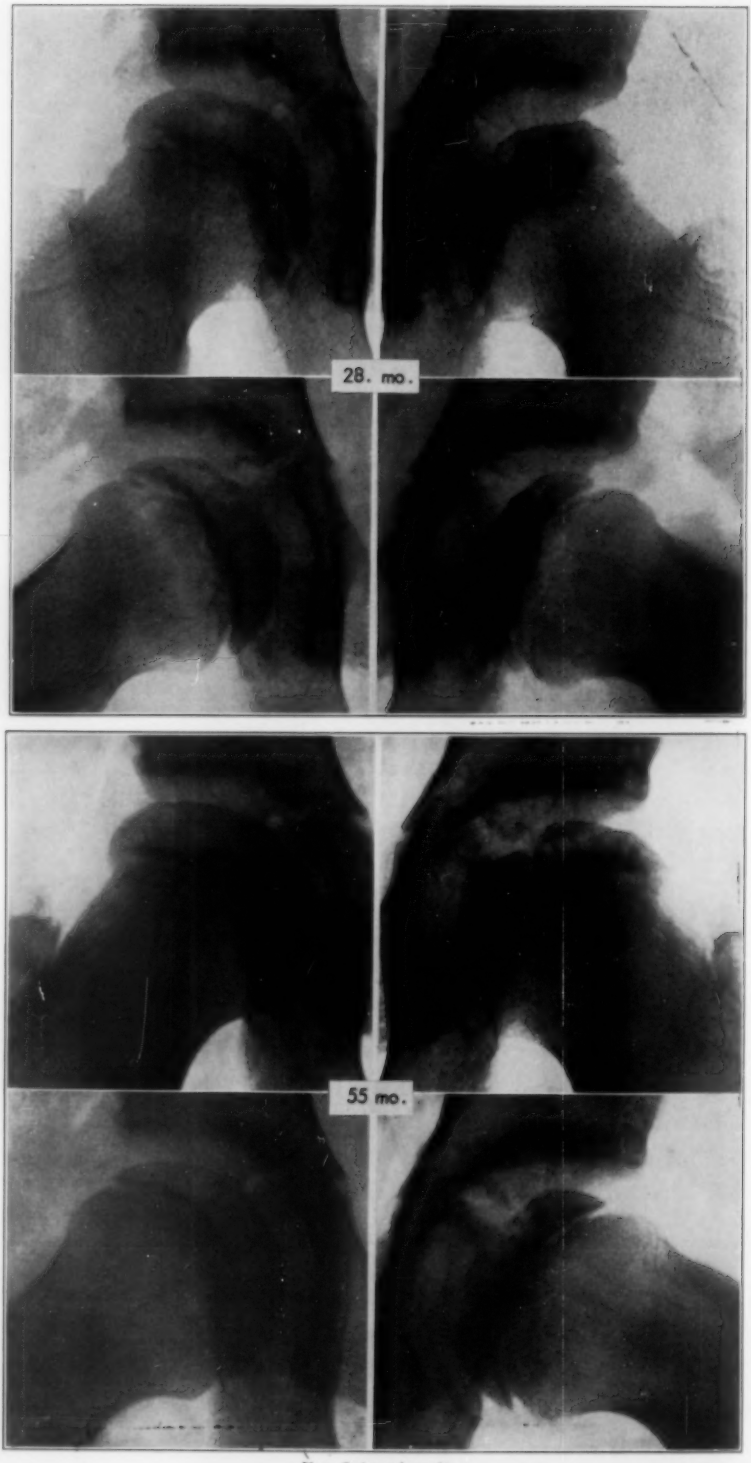


FIG. 2 *(continued)*

with more radiolucent areas. In children, as in adults, it is the weight-bearing portion of the femoral head that usually collapses, and the replacement of this area by new bone may be very irregular and take a long time. The posterior portion of the femoral head usually does not collapse and it is replaced rapidly by new bone by creeping substitution without great alteration in the shape of the femoral head. In children, reossification starts at the margin of the femoral head since no vessels can penetrate the epiphyseal plate.

A comparative study of the anteroposterior and lateral roentgenograms of the femoral head obtained at three-month intervals provided a means to evaluate approximately the extent of the necrotic bone and the speed of its replacement by new bone. The amount of new-bone replacement was charted at three-month intervals as the per cent of the medial and lateral halves of the femoral head as seen in the anteroposterior view and as the per cent of the anterior and posterior halves as seen in the Lauenstein position (Fig. 3 and Chart II). The graph gives an objective indication of the speed of femoral-head reconstruction.

Early roentgenographic signs were studied in patients seen a few weeks after the onset of symptoms and in patients with bilateral disease with initial unilateral

FIG. 2 *(pages 264, 265, and 266)*

Anteroposterior and lateral roentgenograms of the hips of a boy, who was seven years old at onset of limp and pain in the right thigh. He was first seen nine months after onset of symptoms.

In the first roentgenograms, the bone of the right femoral head was necrotic and fragmented and the epiphyseal plate was wide and irregular. Clinically and roentgenographically the left hip appeared to be normal. Traction in bed was applied for eight days to relieve spasm of the right hip adductor muscles; this was followed by a right plaster hip spica cast worn for three months without weight-bearing. L-triiodothyronine, fifty micrograms daily, was then started and was continued for twenty months. Partial weight-bearing with crutches was allowed for two and one-half years after plaster-cast immobilization.

In the roentgenograms made sixteen months after onset of symptoms in the right hip, the posterior half of the right femoral head was reossified and periosteal new-bone formation was seen along the upper margin of the femoral neck. The left femoral head was slightly collapsed, but the patient had no symptoms, although he walked with crutches with partial weight-bearing on the right foot and full weight-bearing on the left.

Further reossification of the right femoral head and more collapse in the left were observed in the roentgenograms obtained nineteen months after onset of symptoms in the right hip. The patient did not have pain in either hip and had only slight restriction of rotation in both hips.

A major collapse of the left femoral head was observed in the roentgenograms made twenty-five months after onset of symptoms in the right hip; the patient had complained of pain in the left hip only for one month before these roentgenograms were obtained.

The reossification of the right femoral head was complete in the roentgenograms obtained twenty-eight months after onset of symptoms in the right hip.

The left femoral head was almost completely reossified in the roentgenograms obtained at fifty-five months.

involvement. At first, the center of ossification of the femoral head was slightly denser and smaller than that on the normal side. Some collapse of the weight-bearing portion of the femoral head was present in all our patients, even in the roentgenograms made only a few days after the onset of symptoms. This collapse presumably occurred after the head had been dead for about three months, as observed in the patients with bilateral disease in whom involvement of the normal hip developed during treatment. Sometimes, there was a fringe of decreased density surrounding the collapsed area, but in other instances collapse occurred without roentgenographic indication that bone absorption had started. Increase in width of the space between the ossified portion of the femoral head and the inner wall of the acetabulum (Waldenström's sign) was observed in most early cases.

The reconstruction of the necrotic femoral head in the sixty-six hips of our patients over four years of age occurred according to three patterns.

Group I: In the most common pattern (thirty-eight hips), the posterior

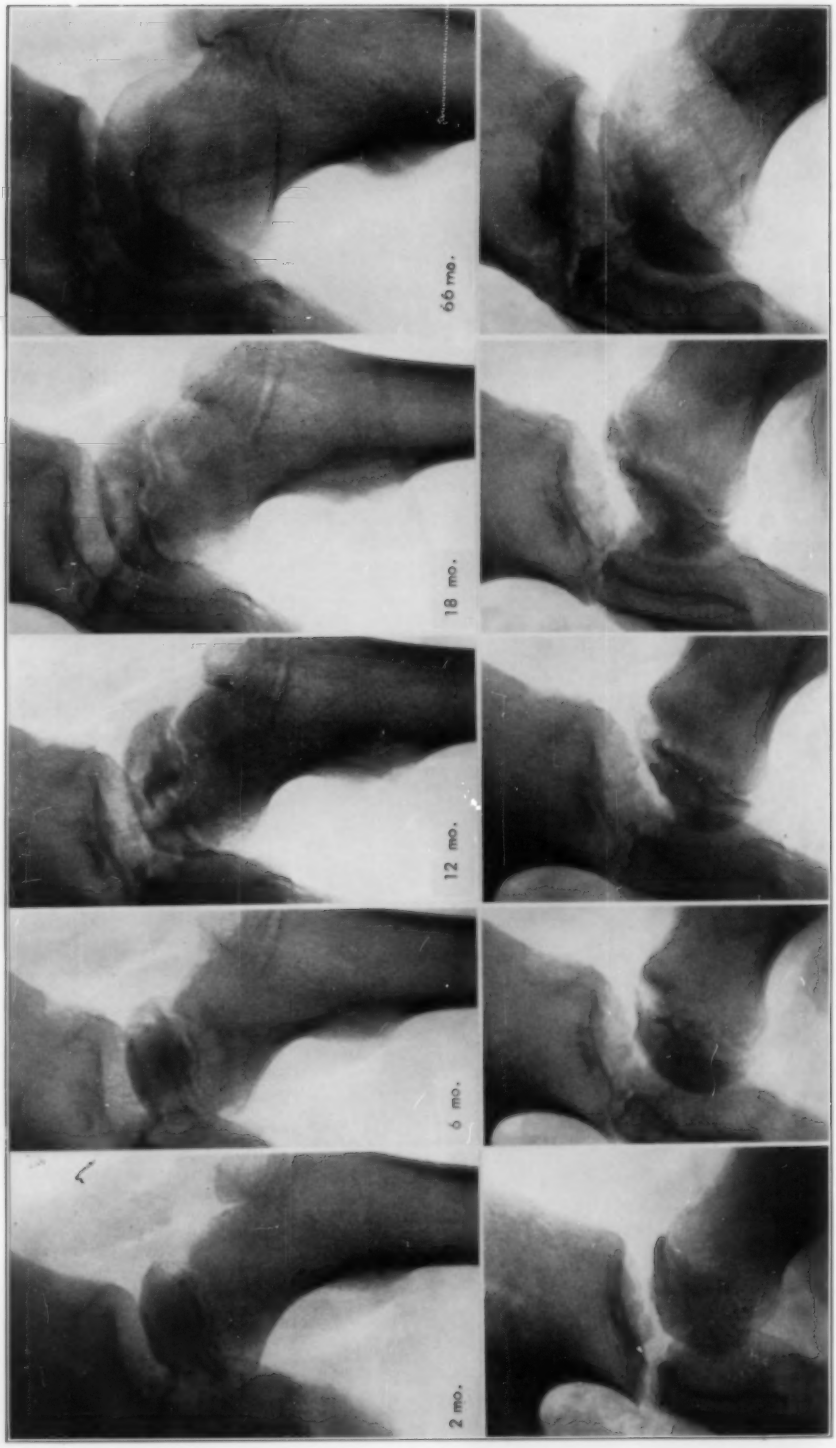


FIG. 3

FIG. 3 *(page 268)*

Anteroposterior (top) and lateral (bottom) roentgenograms of the left hip of a girl, six years old at onset of limp and pain in the thigh. Roentgenograms were made at two, six, twelve, eighteen, and sixty-six months after onset of symptoms. Treatment consisted in bedrest for one week; non-weight-bearing on the left foot for fourteen months, using crutches and a sling; and partial weight-bearing for six more months, using only crutches. The posterior third of the femoral head did not collapse and was reossified in twelve months. The bone of the anterior two-thirds of the head collapsed severely and was not completely reossified, even five and one-half years later. The epiphyseal plate was slightly irregular.

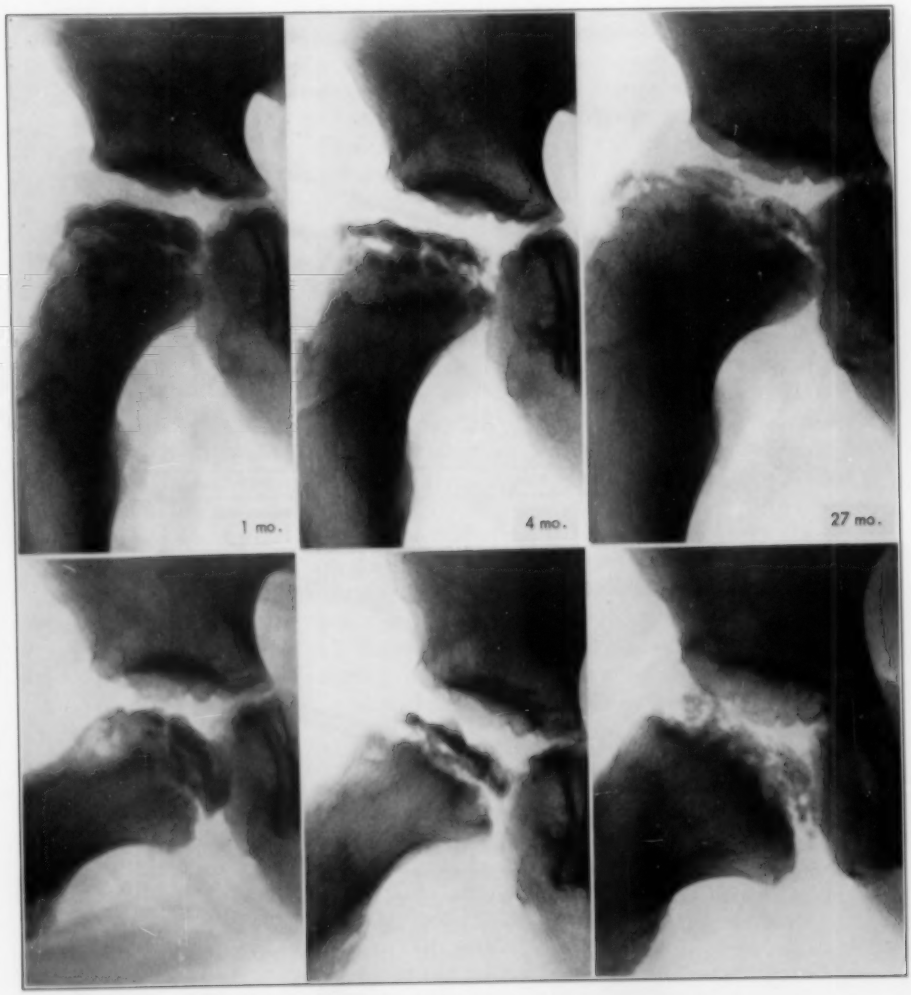


FIG. 4

Anteroposterior (top) and lateral (bottom) roentgenograms of the right hip of a boy, seven years old at onset of pain in the right hip following a fall from a bicycle. Roentgenograms were made at one, four, and twenty-seven months after onset of symptoms. The patient walked with crutches with a sling on the right limb during the first three months of treatment. Buck's traction was then applied for two weeks to relieve severe spasm of the flexor and adductor muscles of the hip. This was followed by the application of a right hip spica plaster cast, which was worn for three months. The patient was then allowed to walk with crutches non-weight-bearing with a sling for seven months and with partial weight-bearing for four more months. L-triiodothyronine, fifty micrograms daily, was administered for one year. The entire femoral head collapsed and reossification was slow and spotty. The epiphyseal plate was wide and irregular. Large areas of decreased density were observed in the metaphysis. The femoral head and neck became very wide and the hip subluxated.

third of the epiphysis was rebuilt at a fast rate, and the collapse in this area was slight. The bone density was increased at first and gradually became normal in one or two years. Bone of less density was commonly observed to spread from the posterior border of the head rapidly at first and then considerably slower after replacement of the posterior third or half of the epiphysis had been completed. Apparently, the new bone was laid down over the dead bone and then this was slowly replaced. The anterior half of the epiphysis ossified at a much slower pace and only after the necrotic bone had first crumbled. An ossification front composed of bone of decreased density could be seen at the anterior border of the

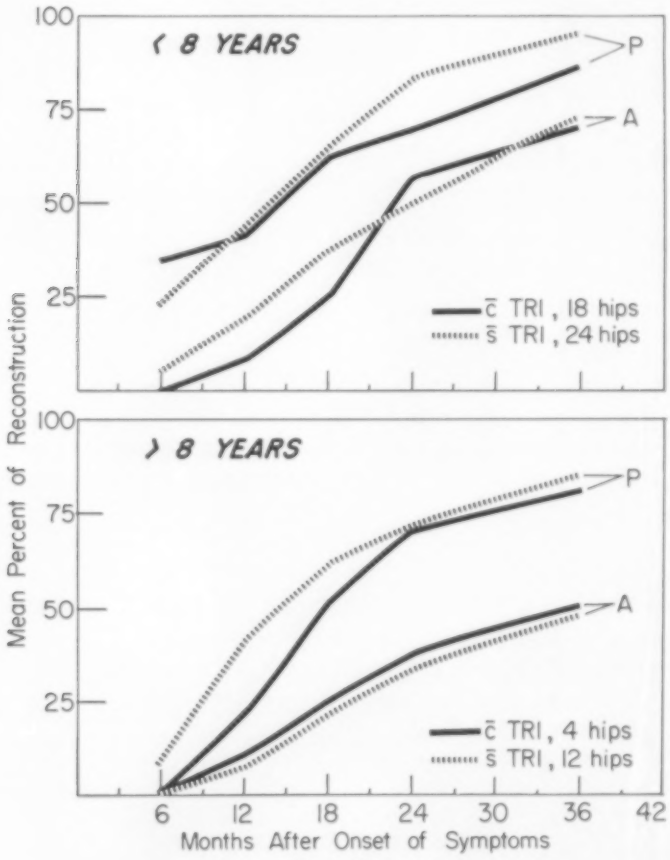


CHART III

The average speed of reossification of the anterior (*A*) and posterior (*P*) halves of the femoral head as seen in lateral roentgenograms of patients who were under and over eight years of age at onset of symptoms and were treated with or without l-triiodothyronine.

head; this front usually extended only through the anterior fourth or third of the head where it met the posterior front of ossification. The ossification of the anterior portion of the head was very irregular and several months elapsed between the absorption of the very dense, old, crumbled, necrotic bone and the formation of the radiolucent new bone. The epiphyseal plate in this group appeared slightly wider than normal and irregular. The ossification in the metaphysis was only slightly altered, although areas of decreased density were seen in relation to the

anterior third of the epiphyseal plate and in the metaphysis in a few cases (Fig. 2).

Group II: In seventeen hips the pattern of reconstruction of the necrotic femoral head was initially similar to that in Group I. However, the collapse of the anterior two-thirds of the femoral head was very severe. The posterior third of the femoral head did not collapse and became reossified in about eighteen months. The posterior front of reossification that usually appeared as bone of less density did not proceed forward and the anterior two-thirds of the epiphysis, once the dead bone had been absorbed, remained largely unossified for many months and even years. The roentgenographic appearance of the epiphyseal plate and metaphysis was similar to that in Group I (Fig. 3).

Group III: The pattern of epiphyseal reconstruction in eleven hips was different from that in Groups I and II. In these hips the bone of the entire femoral head collapsed and the reossification was very slow and irregular. Small, radiolucent areas of new-bone reconstruction appeared at different sites in the head several months after the disorderly removal of crumbled, dense necrotic bone. The epiphyseal plate in these hips was wide and irregular with large areas of decreased density extending deep into the metaphysis (Fig. 4).

The final shape of the femoral head tended not to be greatly altered in Group I, it was flat in Group II, and extremely flat in Group III. The age incidence of the different types of femoral-head reconstruction is illustrated in Chart I. Group I is most common in the younger age groups but the severe forms of Legg-Calvé-Perthes disease (Group III) occur with approximately the same frequency in all ages from four to ten years (Chart I).

The width of the femoral neck increased in all cases of Legg-Calvé-Perthes disease, presumably owing to the increase in periosteal new-bone formation along the neck. In the cases in Group III, roentgenographic evidence of periosteal new-bone formation seemed to appear after the periosteum had been lifted away from the femoral neck (Figs. 2 and 4). As a rule, the greatest amount of periosteal new bone was seen along the upper margin of the femoral neck. The increase in periosteal new-bone formation appeared to be related to the severity of the epiphyseal-plate lesion and to the collapse of the femoral head. However, this new-bone formation was not limited to the area of the neck adjacent to the metaphysis; rather, it extended over the entire length of the neck.

RESULTS OF TREATMENT

The administration of l-triiodothyronine did not appear to change the evolution of the disease in the series reported here. The patients tolerated the drug well in the doses administered, without any untoward effects, but the speed of reconstruction of the epiphyses was not altered. Unfortunately, it was not possible to begin treatment with l-triiodothyronine until an average of three months after the onset of symptoms, when the femoral head appeared necrotic in the roentgenograms. However, Legg-Calvé-Perthes disease developed in the normal hip of one patient who was receiving l-triiodothyronine for involvement of the other hip. There was no evidence that the cause of the disease in the initially normal hip was influenced by the drug (Fig. 2). Similarly, no benefit was observed in the patients who were started on l-triiodothyronine at the onset of symptoms, when only minimum initial roentgenographic changes were present. During the experiment we had the impression that the younger children responded better than the older ones to the drug, but this impression was not borne out when the graphs of speed of reossification of the paired cases were compared (Chart III). The bone age, which at the onset of the disease was retarded an average of one and one-half years in relation to the chronological age, was not altered by prolonged administration of l-triiodothyronine.

DISCUSSION

The use of a thyroid hormone in the treatment of Legg-Calvé-Perthes disease is, of course, not new. A possible relationship between Legg-Calvé-Perthes disease and thyroid dysfunction has been entertained by several authors. Lesions like Legg-Calvé-Perthes disease had been observed in patients with cretinism; many years ago Albright called attention to the fact that changes simulating Legg-Calvé-Perthes disease could occur in the epiphyses of many bones in juvenile myxedema. Thyroid function in patients with Legg-Calvé-Perthes disease was studied by several investigators. Emerick and associates used radioactive iodine tracers as a measure of thyroid activity and stated that none of the patients studied was found to have normal thyroid function. Abnormalities discovered were pure hypothyroidism and thyroid adenomata with relative hypothyroidism. These authors felt that the Legg-Perthes disease in their patients responded more rapidly to conventional therapy after the adenomata, if present, had been removed surgically and the patients had been placed on thyroid substance in a full-tolerance dosage. No other investigators have been able to corroborate these findings. Chapman studied the forty-eight-hour uptake of radioactive iodine by the thyroid gland and the serum protein-bound iodine in ten children with Legg-Perthes disease; no evidence of thyroid dysfunction could be discovered in these patients. Chapman further stated that clinicians over the past twenty-two years found no evidence of thyroid disease in sixty-five children with Legg-Perthes disease treated at the New England Peabody Home; one patient did have panhypopituitarism with hypothyroidism as part of the syndrome, and yet the course of his Legg-Perthes disease seemed unaltered by thyroid, 120 milligrams administered daily for four of the six years he was in the home. Katz could not find any abnormality in the protein-bound iodine in patients with Legg-Calvé-Perthes disease, nor were any clinical stigmata of hypothyroidism observed in his cases. Beiler and Love also reported normal thyroid function in their patients with Legg-Calvé-Perthes disease. We studied the protein-bound iodine and the uptake of radioactive iodine by the thyroid gland in twenty patients with Legg-Calvé-Perthes disease; values within normal ranges of thyroid function were found in all twenty.

The use of l-triiodothyronine in the treatment of patients with Legg-Calvé-Perthes disease was based on experimental work [14]. The histological similarities between the epiphyseal-plate lesions observed in patients with Legg-Calvé-Perthes disease and in animals treated with aminonitriles do not, of course, imply a common etiology. The epiphyseal-plate lesion in human patients responsible, as we believe, for the interruption of the blood supply to the femoral head possibly may be related to an inborn error of metabolism [3]. However, the suppression of the aminoacetonitrile lesions in animals with l-triiodothyronine encouraged us to treat children with Legg-Calvé-Perthes disease with high doses of l-triiodothyronine in an effort to correct the epiphyseal-plate lesions and thus favor an early revascularization of the necrotic femoral head. The failure of l-triiodothyronine to alter the speed of reconstruction of the necrotic femoral head in our series of cases appears to indicate that the compound does not alter the lesion in the upper femoral epiphyseal plate. It would also appear that thyroid therapy in children with Legg-Calvé-Perthes disease is probably useless.

In the series reported here the hip was not symptomatic unless some collapse of the femoral head had occurred. Slight increase in density and some decrease in size of the center of ossification of the femoral head in relation to the normal side were the earliest roentgenographic signs. Presumably, the necrosis of the femoral head preceded the symptoms by about three months. After onset of the necrosis,

growth was interrupted in the center of ossification of the femoral head, pending revascularization. This, combined with the slight collapse of the weight-bearing portion of the necrotic femoral head, contributed to the smaller size of this center of ossification.

The slight separation of the femoral head from the inner wall of the acetabulum (Waldenström's sign) was probably due to edema and inflammation of the synovial membrane lining the acetabular fossa and to the increase of synovial fluid in the joint [7]. In our experience this synovitis usually followed epiphyseal necrosis and bone collapse.

Often, children are seen with tenderness in the hip area, limp, and slight limitation of hip motion with negative roentgenograms, except for a slightly positive Waldenström sign. These symptoms, presumably due to non-specific synovitis of the hip joint, disappear in a few weeks and Legg-Calvé-Perthes disease rarely develops. From our experience, we doubt that there is a relationship between so-called non-specific synovitis of the hip joint and Legg-Calvé-Perthes disease.

Recently, O'Garra stated that the evolution and prognosis of Legg-Calvé-Perthes disease depended on the extensiveness of the initial area of necrosis of the femoral head. When the whole epiphysis was involved, reconstruction was slow with severe loss in height; whereas, if only a part (the anterior) of the femoral head was necrotic, reconstruction was completed rapidly and the result was better. In our series, all patients over four years of age probably had total femoral-head necrosis initially. Five children, one to three years of age at onset of disease, may have had partial necrosis. Great collapse of the femoral head does not occur at that age and reossification probably proceeds slowly from multiple sites [15].

As observed on the roentgenograms, new-bone formation did not follow along the path of the epiphyseal vessels, which presumably were occluded at the edge of the disrupted epiphyseal plate. It would appear that new vascular channels had to form to revascularize the necrotic femoral head. The replacement of dead bone by new bone was very slow and irregular, suggesting that it was difficult for the retinacular vessels to form new channels across the edge of the abnormal, softened epiphyseal plate. The degree of severity of the epiphyseal-plate lesion appeared to be a sign of great prognostic value with respect to the speed of reconstruction of the necrotic femoral head. Presumably, the wider and more deranged the plate became, the greater was the barrier offered to revascularization of the head. Reconstruction of the head was very slow and disorderly in the patients with a wide and irregular epiphyseal plate and metaphysis (Group III). Faster reossification was observed in patients with milder epiphyseal-plate lesions (Groups I and II). The posterior third of the femoral head reossified at a faster rate, possibly because of the greater abundance of retinacular vessels available in that site, as compared with the scarcity or even absence of vessels in the anterior part of the head [16]. Presumably, the posterolateral and posteromedial retinacular vessels penetrated the posterior portion of the epiphysis and the necrotic area was rebuilt even before severe collapse had occurred. Also, the revascularization of the crumbled dead bone of the weight-bearing portion of the femoral head was slower than the revascularization of the posterior, non-weight bearing portion, which often did not collapse. The patients in Group II tended to be older than those in Group I at the onset of symptoms and they had a much greater collapse in the anterior two-thirds of the femoral head. After advancing through the posterior one-third of the head, the posterior front of ossification, as seen on the roentgenogram, was apparently stopped for many months at a zone of crumbled, necrotic, bone trabeculae and fibrocartilage. The dead bone continued to be slowly absorbed, but the capacity to form new bone was apparently exhausted.

The great amount of periosteal new bone seen most often along the upper margin of the femoral neck in the severe forms of Legg-Calvé-Perthes disease is of great interest to us because one of the earliest signs of minimum aminonitrile poisoning in vertebrates is periosteal new-bone formation on the femoral neck [11].

SUMMARY

We suspect that the primary lesion in Legg-Calvé-Perthes disease is a weakening and disruption of the upper femoral epiphyseal plate. Aseptic necrosis of the femoral head results from the interruption of the retinacular vessels when they cross the cartilage at the edge of the disrupted plate.

Early clinical signs of Legg-Calvé-Perthes disease are related to synovitis, which usually follows total femoral-head necrosis and collapse of the center of ossification.

The speed of recovery of the necrotic epiphysis is related to the severity of the epiphyseal-plate lesion and of bone collapse.

No evidence of thyroid dysfunction was discovered in our patients. Administration of large doses of l-triiodothyronine during periods of from six to eighteen months did not alter the speed of reconstruction of the necrotic femoral head.

REFERENCES

1. Albright, Fuller: Changes Simulating Legg-Perthes Disease. (Osteochondritis Deformans Juvenilis Due to Juvenile Myxoedema.) J. Bone and Joint Surg., **20:** 764–769, July 1938.
2. Beiler, D. D., and Love, W. H.: Thyroid Function in Legg-Perthes Disease. J. Bone and Joint Surg., **38-A:** 1320–1322, Dec. 1956.
3. Burian, H. M.; von Noorden, G. K.; and Ponseti, I. V.: Chamber Angle Anomalies in Systemic Connective Tissue Disorders. Arch. Ophthal., **64:** 671–680, 1960.
4. Chapman, E. M.: Thyroid Function in Legg-Perthes Disease. New England J. Med. **255:** 289–290, 1956.
5. Emerick, R. W.; Corrigan, K. E.; Joistad, A. H., Jr.; and Holly, L. E.: Thyroid Function in Legg-Calvé-Perthes Disease—A New Approach to an Old Problem. Clin. Orthop., **4:** 160–165, 1954.
6. Evans, D. L., and Lloyd-Roberts, G. C.: Treatment in Legg-Calvé-Perthes' Disease. A Comparison of In-patient and Out-patient Methods. J. Bone and Joint Surg., **40-B:** 182–189, May 1958.
7. Howorth, M. B.: Coxa Plana. J. Bone and Joint Surg., **30-A:** 601–620, July 1948.
8. Katz, J. F.: Protein-Bound Iodine in Legg-Calvé-Perthes Disease. J. Bone and Joint Surg., **37-A:** 842–846, July 1955.
9. Mindell, E. R., and Sherman, M. S.: Late Results in Legg-Perthes Disease. J. Bone and Joint Surg., **33-A:** 1–23, Jan. 1951.
10. O'Garra, J. A.: The Radiographic Changes in Perthes' Disease. J. Bone and Joint Surg., **41-B:** 465–476, Aug. 1959.
11. Ponseti, I. V.: Lesions of the Skeleton and of Other Mesodermal Tissues in Rats Fed Sweet-Pea (*Lathyrus Odoratus*) Seeds. J. Bone and Joint Surg., **36-A:** 1031–1058, Oct. 1954.
12. Ponseti, I. V.: Legg-Perthes Disease. Observations on Pathological Changes in Two Cases. J. Bone and Joint Surg., **38-A:** 739–750, July 1956.
13. Ponseti, I. V.: Prevention of Aminonitrile Lesions in Rats with L-Triiodothyronine. Proc. Soc. Exper. Biol. and Med., **96:** 14–17, 1957.
14. Ponseti, I. V.: Studies of the Suppression of Aminonitrile Lesions in Rats by Thyroxine Analogues. Endocrinology, **64:** 795–806, 1959.
15. Trueta, Joseph: The Normal Vascular Anatomy of the Human Femoral Head During Growth. J. Bone and Joint Surg., **39-B:** 358–394, May 1957.
16. Tucker, F. R.: Arterial Supply to the Femoral Head and Its Clinical Importance. J. Bone and Joint Surg., **31-B:** 82–93, Feb. 1949.

Isolated Displaced Fracture of the Posterior Facet of the Talus

BY J. H. DIMON, III, M.D., BOSTON, MASSACHUSETTS

From the Fracture Clinic of the Massachusetts General Hospital, Boston

Isolated displaced fracture of the posterior facet of the talus has not been accurately documented in the English literature. Bonnin mentioned a fracture

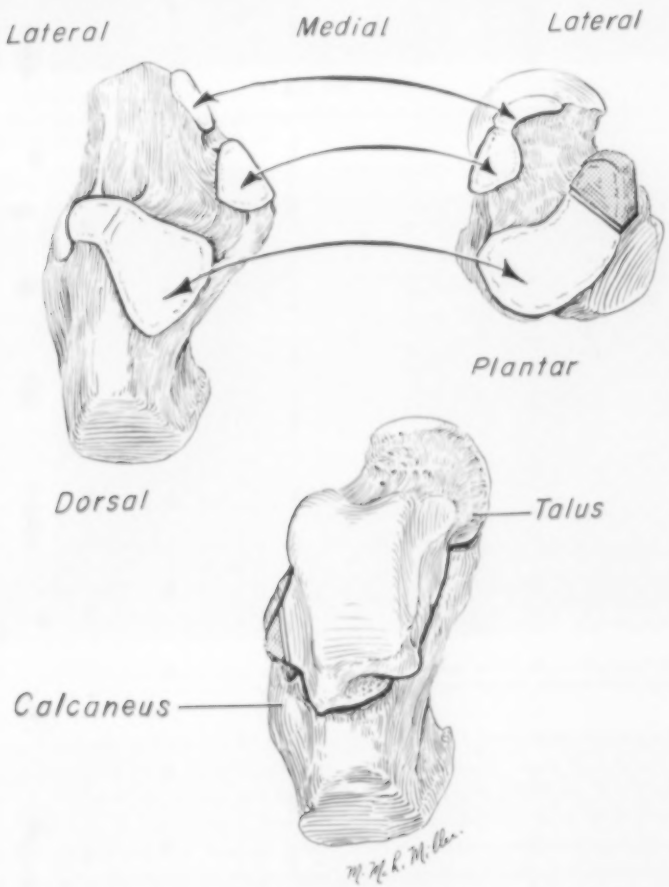


FIG. 1

Drawing of calcaneus and talus, disarticulated (above) and articulated (below). The stippled area represents the fracture fragment of the posterior facet of the left talus.

of the lateral process of the talus that is usually undisplaced and satisfactorily treated by immobilization in plaster, without weight-bearing, for three or four weeks, followed by weight-bearing in a plaster boot until the eighth week after the accident. Milch and Milch described a fracture of the talus involving its lateral mass and the articular surface of the fibula, a fracture that they believed

FIG. 2-A

Case 1. Preoperative roentgenograms of the left ankle six months after injury. Note the prominence and slight step-off on the articular surface of the talus just beneath the lateral malleolus on the anteroposterior view.

FIG. 2-B

Roentgenograms made three years and seven months after operation. Note the narrowing of the subtalar joint on the lateral view.

needed no more treatment than immobilization of the foot in the neutral position for the control of pain. These descriptions undoubtedly refer to undisplaced fractures; however, isolated displaced fractures of the posterior facet of the talus do occur and they pose problems in diagnosis and treatment. It is hoped that the documentation of three cases in which the diagnosis was proved at surgery will stimulate interest in this fracture, which may cause considerable disability.

This fracture involves the anterolateral articular surface of the posterior facet of the talus, thereby entering the posterior subtalar joint (Fig. 1).

It has been impossible to ascertain the exact mechanism of injury from questioning of the patients. The trauma described might have caused the usual ankle sprain or fracture. No episode of inversion or eversion could be recalled by the patients.

The physical findings are indistinguishable from those associated with a sprain of the anterior talofibular ligament and associated soft tissues. Swelling and tenderness are present over the anterolateral aspect of the foot just in front

FIG. 3-A

Case 2. Roentgenograms at the time of injury. Note the step-off and prominence of the talus just below the lateral malleolus on the anteroposterior view. The mortise and lateral views do not demonstrate the fracture.

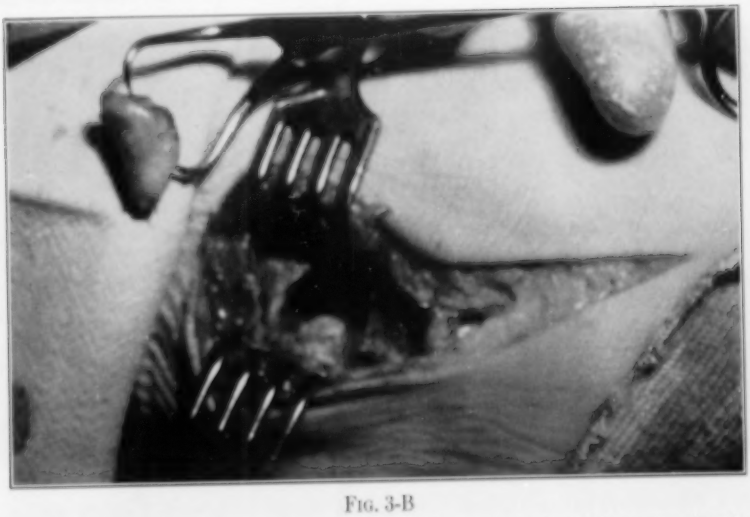


FIG. 3-B

The excised fragment at the time of operation. Note the amount of articular surface (to the left) on the fragment. The toes are to the right.

of the lateral malleolus. Crepitus has not been elicited on initial examination. Roentgenographic examination, including anteroposterior, lateral, and mortise views of the ankle, may be read by the unwary as negative for bone injury and perhaps as showing soft-tissue swelling.

REPORT OF CASES

CASE 1 (MGH 947984). A male ski instructor, twenty-two years old, injured his left ankle while skiing in 1956. Roentgenograms were interpreted as showing an ankle fracture, and a leg walking-cast was worn for six weeks. Because of persistent pain and inability to work, new roentgenograms were made six months after the initial injury; these revealed a displaced fracture of the posterior facet of the talus (Fig. 2-A). At operation, a displaced ununited fragment of the anterolateral aspect of the posterior facet of the left talus, measuring approximately two by one by two and one-half centimeters, was removed. There was a lapse of one and one-half years after operation before the patient could tolerate skiing with his ankle taped.

Follow-up examination at three years and seven months after operation disclosed that the patient was then able, with his ankle taped, to work as a skiing instructor, but he had mild twinges

FIG. 3-C

Roentgenograms made six months after operation. Note the narrowing of the subtalar-joint space on the lateral view. A bone flake left behind at operation can be seen beneath the lateral malleolus on the anteroposterior view.

FIG. 4-A

Case 3. Preoperative roentgenograms. Note that the fracture in the talus is readily seen on the anteroposterior view but not in the other views.

FIG. 4-B

Roentgenograms made six months after operation. The small screw is seen, and the fracture is united.

of pain with every step and was unable to stand on tiptoe on the left foot. Subtalar motion was accompanied by crepitus and was limited (inversion was 15 degrees on the right and 0 degree on the left, and eversion was 20 degrees on the right, and 10 degrees on the left). Roentgenograms showed narrowing of the subtalar-joint space (Fig. 2-B).

Case 2 (MGH 360313). A laborer, thirty-one years old, fell approximately ten feet, landing on and twisting his right ankle in December 1958. The physical findings were consistent with the diagnosis of severe sprain of the anterior talofibular ligament of the ankle; the roentgenograms were reported as negative. For three weeks, a leg walking-cast was worn, and then the ankle was strapped for four weeks. Repeat roentgenograms made seven weeks after injury were again reported as negative, but the patient continued to have intermittent severe pain in the ankle aggravated by use; he was unable to do full-time work. Roentgenograms made seven months after the injury revealed a fracture of the posterior facet of the talus, and review of his initial roentgenograms showed that the fracture was visible on these also (Fig. 3-A). Because of persistent pain and disability, operation was performed eleven months after the initial injury. A large fragment from the anterolateral aspect of the posterior facet of the talus was found to be externally rotated and displaced laterally and superiorly. It could not be reduced into satisfactory position owing to the ingrowth at the fracture site of fibrocartilaginous tissue; accordingly, it was excised (Fig. 3-B). After operation, the patient was treated in a non-weight-bearing plaster cast for four weeks and then for an additional three weeks in a non-weight-bearing bivalved cast, which was removed for periodic exercises.

Six months after operation, the patient was unable to work full time because of persistent pain with use of the right foot. He was unable to stand on tiptoe on the affected limb. Subtalar motion was accompanied by crepitus, and movement of the joint was decreased (20 degrees of inversion on the left, and 15 degrees on the right; 15 degrees of eversion on the left, and 5 degrees on the right). Roentgenograms showed narrowing of the subtalar-joint space (Fig. 3-C).

Case 3 (MGH 1078320). A secretary, eighteen years old, injured both her ankles in an automobile accident in November 1959. The physical findings were consistent with a diagnosis of sprain of the anterior talofibular ligament of both ankles. Roentgenograms showed no fracture of the right ankle, but in the left ankle there was a displaced fracture of the posterior facet of the talus, with a small fragment off the tip of the lateral malleolus (Fig. 4-A). At operation nine days after injury, a large fragment of the anterolateral portion of the posterior facet of the left talus was found to be displaced superiorly and laterally. The anterior talofibular ligament was primarily inserted superior to the fragment with approximately one-third of its fibers attaching to the fractured portion. It was easily reduced and held in anatomical position by a small screw introduced from the sinus tarsi and aimed in a posterosuperior direction. The head of the screw was countersunk. After operation, the ankle was treated in a non-weight-bearing leg cast for six weeks, and then in a bivalved cast, which was removed for exercises, for an additional four weeks. The patient was able to return to work eight weeks after her injury.

Follow-up examination six months after operation revealed that the patient had no complaints with reference to the left foot and ankle. She could walk, run, and jump without discomfort, and could stand on tiptoe on the left foot. Subtalar motion was smooth, without crepitus, but lacked 5 degrees of inversion and eversion when compared with the normal side. Roentgenograms revealed union of the fracture, with no evidence of avascular necrosis of the fragment (Fig. 4-B).

Thirteen months after operation, the left foot was still asymptomatic and normal to physical examination. Roentgenograms showed no aseptic necrosis or narrowing of the joint space.

MECHANISM OF INJURY

Three mechanisms of injury might be postulated:

1. The fragment is sheared off the posterior facet of the talus by the lateral malleolus when the foot is forced into eversion (Fig. 5);

2. The fragment is avulsed by the anterior talofibular ligament when the foot goes into inversion (Fig. 5); and

3. The fragment is sheared off the posterior facet of the talus by the corresponding area of the calcaneus during forced dorsiflexion and external rotation of the foot (Fig. 5).

In the first mechanism of injury, the foot would have to go into marked eversion and external rotation, but as I have not seen clinical evidence of sprain of the deltoid ligament or associated fracture of the medial malleolus, I do not believe that this fracture is an external-rotation eversion injury.

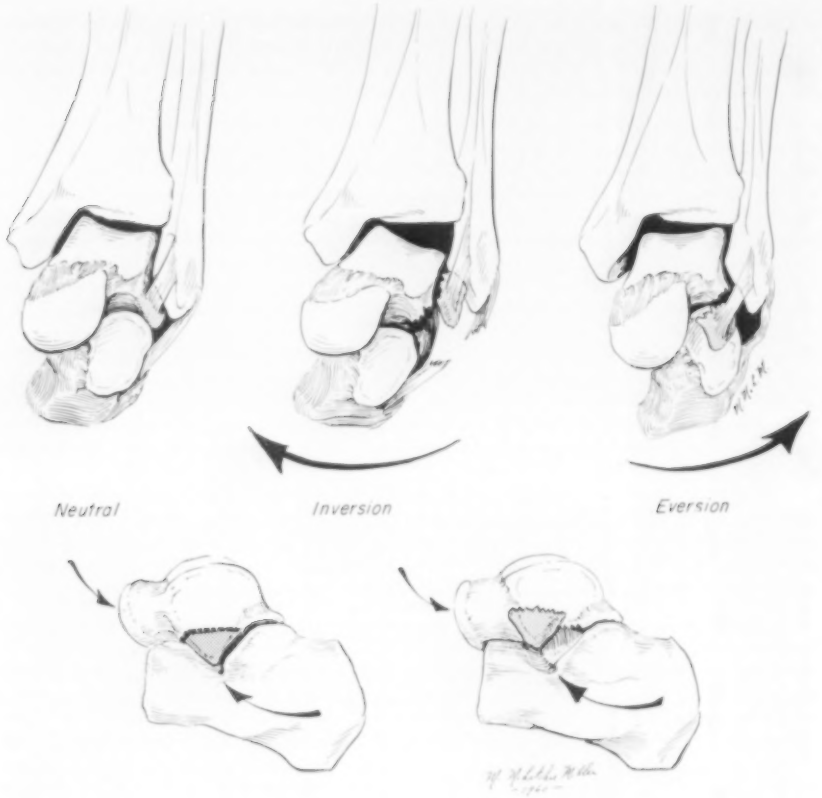


FIG. 5

Illustrations of possible mechanisms of injury. The probable mechanism is compression. The fragment is sheared off the posterior facet of the talus by the corresponding area of the calcaneus as the foot is forced into dorsiflexion and slight external rotation.

The anterior talofibular ligament normally is attached to the talus superior to the site of the fracture, too high for it to cause an avulsion fracture in this precise site. In two patients, at operation, the ligament was found to be primarily inserted superior to the fragment, except for approximately one-third of its fibers which were attached to the fragment. If inversion were the true mechanism of injury, one would expect this fracture to be seen more frequently, considering the great number of inversion injuries that occur.

It is probable that the mechanism is compression caused by dorsiflexion and slight external rotation of the foot. These movements lock the posterior facet of the calcaneus behind the corresponding facet of the talus, and, as dorsiflexion of the foot continues, the anterolateral portion of the articular surface of the talus is sheared off and displaced.

DIAGNOSIS

The correct diagnosis can be made from roentgenograms of the ankle if this fracture is always looked for and suspected in any ankle injury. The fracture in each of these three cases just reported was apparent to careful scrutiny on one of the standard roentgenographic views. In the event of doubt, several oblique

FIG. 6-A FIG. 6-B FIG. 6-C

Fig. 6-A: Case 3. Anteroposterior view of the left ankle, with the leg in 20 degrees of external rotation. Note how the fracture fragments stand out.
Fig. 6-B: Comparative view of the opposite normal foot.
Fig. 6-C: Anteroposterior view of the ankle with the foot in 45 degrees of internal rotation and 30 degrees of equinus position. The fragment is seen beneath the posterior subtalar joint overlying the calcaneus (arrows).

views should be made, including an anteroposterior view with the foot in 45 degrees of internal rotation and 30 degrees of equinus position. A roentgenogram in this projection may show the fracture because the posterior subtalar joint is shown in profile (Figs. 6-B and 6-C).

TREATMENT

No definite conclusions as to the best treatment of this fracture can be drawn from these three cases. It appears, however, that if the fracture is not recognized initially, prolonged disability occurs that is not adequately relieved by excision of the fragment. Perhaps, in the future, subtalar arthrodesis will be necessary in the two cases in which the diagnosis was not made initially. It is too early to evaluate the result of the patient who was treated by initial open reduction and fixation of the fragment. However, when last examined, this woman appeared to have a normal subtalar joint. Only longer follow-ups and more clinical material will determine the best method of treatment.

CONCLUSION

Isolated displaced fractures of the posterior facet of the talus do occur, and they can be diagnosed if one is alert to this possibility when studying the roentgenograms of the ankle. It is possible that it is this injury undiagnosed that causes some of the chronically painful so-called sprained ankles that are such problems at times. Certainly, in every case of ankle sprain resistant to the usual conservative treatment, the roentgenograms should be reviewed and repeated with this fracture in mind. Early diagnosis appears to be of paramount importance. Early open reduction and fixation may avoid prolonged disability and pain.

REFERENCES

1. BONNIN, J. G.: Injuries to the Ankle, p. 385. New York, Grune and Stratton, 1950.
2. MILCH, HENRY, and MILCH, R. A.: Fracture Surgery, p. 452. New York, Paul B. Hoeber, 1959.

A Foreign Body in a Tendon Sheath

Case Report

BY AMIN RIDA, M.CH. ORTH. (ALEX.), ALEXANDRIA, EGYPT, UNITED ARAB REPUBLIC

A foreign body seldom remains within a tendon sheath for prolonged periods of time. The following case of a thorn removed from the sheath of the extensor carpi radialis longus eight years after injury seems sufficiently unusual to warrant publication.

CASE REPORT

A laborer, twenty-six years old, presented himself on October 11, 1958, complaining of a painful swelling on the dorsum of the right wrist. Eight years before, when he was walking in a field, he was pricked by a thorn on the dorsum of the right wrist; he believed that he had removed the thorn completely. On the day after this injury, the site of the thorn prick became swollen, red, hot, and tender, but with local treatment the swelling disappeared in two weeks.

Seven years after the injury, a swelling developed on the dorsum of the wrist and increased in size. Three months later, the tumor became painful, especially on forcible extension of the wrist. All local treatment failed to improve the condition.

When the patient was examined on October 11, 1958, a swelling, eleven by five centimetesr

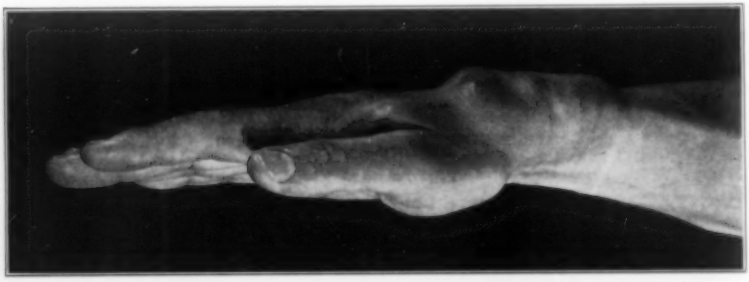


Fig. 1

in diameter, was found on the radial side of the back of the right wrist (Fig. 1). The swelling was oblong and broader in its distal than in its proximal part. There was a constriction in its middle portion at the level of the wrist joint. The mass was tender and cystic; it had well defined edges, and its surface was smooth to palpation. Distally, the mass extended to the base of the second metacarpal bone and was fixed to this bone. The proximal portion of the tumor could be moved from side to side but not in a longitudinal direction. The skin was not fixed to the mass, and the color and temperature of the skin were normal. Active extension and abduction of the wrist against resistance were painful and rendered the swelling tense, immovable, and more prominent. The swelling could not be reduced by pressure. There was no swelling of the wrist-joint space; movements of the wrist were normal. The preoperative diagnosis was chronic tenosynovitis of the extensor carpi radialis longus of the right wrist.

The tumor was excised through a longitudinal incision over the swelling. The mass was found to surround the extensor carpi radialis longus tendon. It appeared to consist of the tendon sheath, which was greatly thickened and composed of dense fibrous tissue. The cavity within the mass contained thick, yellow, turbid fluid. No culture was made since the fluid was spilled at operation. The lining of the central cavity was generally smooth, with a few small, scattered villi and many irregular recesses connecting with the main cavity. A pointed thorn, twelve millimeters long, was found stuck within a shallow depression in the wall (Fig. 2). When the mass was *in situ* the thorn lay in contact with the tendon. The tendon itself appeared normal.

The wound healed by primary intention; the patient had no complaint when seen one year after operation.

FIG. 2

COMMENT

Although inflammatory conditions of tendon sheaths are caused by penetrating wounds, it is unusual for foreign bodies to be retained in them permanently. The literature was searched extensively, but no similar case was found. As a matter of fact, a big foreign body cannot remain inside a synovial sheath because either it is extruded from the wound from which it gained entrance or it destroys the sheath and is displaced into the surrounding tissues. A small foreign body, however, may enter the sheath of a tendon at the time that the puncture wound occurs, or it may work its way into the sheath from the adjacent tissues as the result of chronic inflammation and erosion of the sheath. If this happens, the foreign body would subsequently become enveloped in a fibrous capsule formed as the result of the reaction of the tissues to the foreign body. In the case reported here, it seems possible that the tip of the thorn became embedded in the tendon proper and was broken off when the patient attempted to extract it. Then, with normal movement of the tendon, the small piece of thorn embedded in it was dragged into the sheath, eventually becoming dislodged into the space within the sheath by the continuous gliding of the tendon. Finally, the thorn caused the development of a bed in the wall of the sheath, which became greatly thickened as the result of the chronic inflammation.

SUMMARY

Foreign bodies in tendon sheaths are rare. A case is reported of chronic tenosynovitis caused by a thorn found lying in the sheath of the tendon of the right extensor carpi radialis longus. This thorn had been embedded for eight years before it was discovered.

Proceedings

SOCIÉTÉ INTERNATIONALE DE CHIRURGIE ORTHOPÉDIQUE ET DE TRAUMATOLOGIE

The Eighth Congress of the International Society of Orthopaedics and Traumatology was held at the Hotel Astor, New York, N. Y., September 4 through 9, 1960, with the 1960 Officers of the Society:

President: Dr. Jean Delchef, Brussels, Belgium;
Vice-Presidents: Mr. Joseph Trueta, Oxford, England, and Dr. E. Godoy Moreira, São Paulo, Brazil;
Secretary-General: Dr. Antoine Bailleux, Brussels, Belgium;
Treasurer: Dr. M. J. Cornet, Brussels, Belgium;

The 1960 Officers of the Congress:

President: Mr. Joseph Trueta, Oxford, England;
Vice-President: Dr. Philip D. Wilson, New York, N. Y.;
Secretary: Dr. Lee Ramsay Straub, New York, N. Y.;
Treasurer: Dr. Mather Cleveland, New York, N. Y.; and

The 1960 National Committee:

Honorary Chairman: Dr. Henry W. Meyerding, Rochester, Minnesota;
National Delegates: Dr. Frank E. Stinchfield, *Chairman*, New York, N. Y.;
Dr. Harold A. Sofield, Oak Park, Illinois;
Dr. Ralph Soto-Hall, San Francisco, California;
Secretary-Treasurer: Dr. A. R. Shands, Jr., Wilmington, Delaware;
Program Committee: Dr. Harold B. Boyd, Memphis, Tennessee;
Dr. R. I. Harris, Toronto, Ontario, Canada;
Dr. Alberto Inclan, Havana, Cuba;
Dr. Joseph E. Milgram, New York, N. Y.;
Dr. Ralph Soto-Hall, San Francisco, California;
Dr. José Valls, Buenos Aires, Argentina;
Dr. A. R. Shands, Jr., Wilmington, Delaware.

Summaries of the papers presented follow:

Monday, September 5

Question One: Congenital Dysplasia of the Hip

Reporter: Prof. Bryan McFarland (Great Britain)
Reporter: Dr. Ivar Alvik (Norway)
Co-reporter: Dr. Oscar Scaglietti (Italy)
Co-reporter: Prof. Marino Ortolani (Italy)
Co-reporter: Dr. Paul C. Colonna (U.S.A.)

Prof. McFarland began the discussion by stating the general principles concerning the treatment of this condition—early recognition, early and definitive treatment, and proper long-term evaluation of results. He then gave the schema of evaluation of results, which those attending were urged to follow. His own treatment consisted either in positioning without anesthesia and maintenance of the position or in manipulation with anesthesia followed by maintenance of the reduced position or, lastly, open reduction.

Dr. Alvik discussed his experience with 945 cases of dysplasia and placed emphasis on the very good results to be obtained by prolonged traction with reduction. When this method was followed, or when manipulation, or reduction, or open reduction was done, prolonged non-weight-bearing was also often necessary for excellent results to be obtained.

Dr. Scaglietti reported on patients between the ages of four and five years. For children of this age, he recommended open operation with a wide approach, lengthening of the iliopsoas muscle, and excision of those parts preventing reduction—the limbus, capsular adhesions, the ligamentum teres, pericephalic insertion of the capsule, and the iliopsoas.

Prof. Ortolani described, principally, the development and diagnosis of dysplasias (not including teratological dysplasias) and said that all are varying degrees of the same abnormality, which is hereditary, bilateral, and, except in 2 to 3 per cent of the cases, can be diagnosed by the

Ortolani sign at birth. Many dysplasias do not progress to dislocation—some retrogress and others, untreated, develop to varying degrees. When the disease is merely flattening of the cotyloid cartilage, the Ortolani sign is absent; however, when the limbus is also rounded, and in all further degrees of abnormality, where abduction is still unlimited, it can be elicited. Anatomical studies, correlated with these signs, were shown to illustrate the disease process. In two large series of cases, 50 per cent of all new-born infants showed dysplasia by clinical signs, but roentgenographic and arthrographic studies were of less value.

Dr. Colonna discussed the method of arthroplasty he uses in children between the ages of three and eight years. In bilateral disease, the results were better in children under six. The procedure included adductor myotomy and traction. Sometimes rotational osteotomy was necessary subsequent to arthroplasty.

Discussors of Question One

Congenital Dysplasia of the Hip. Dr. Philip Erlacher (Austria).

Congenital Dislocation of the Hip. Discussion with Particular Reference to Arthrography. Dr. Knud Jansen and Dr. Erik Hjalmar Larsen (Denmark) described the use of routine arthrography in patients with any suspicion of subluxation or congenital dislocation of the hip. They emphasized the information it could give concerning the position of the limbus and stressed the importance of arthrography as a guide during conservative treatment. They also warned of the damage that may occur if arthrography is not performed competently.

The Development of the Upper End of the Femur. Dr. Poul Lutken (Denmark) described a variation in the ossification pattern of the femoral head seen in many mammals and in an occasional human specimen. He believes that this variation is not the result of a disease process, but an embryological disturbance of growth at the hip.

Congenital Dislocation of the Hip. Dr. Augusto Bonilla and Dr. Guillermo Guerra (Ecuador) presented their experience with 338 patients (481 hips) seen during a ten-year period. The majority of patients were female children between the ages of one and three years. Oddly enough for Ecuador, there were no Indian or Negro patients; the authors believe that for the Indian, at least, congenital subluxation either does not exist or is very rare. The authors also believe that arthrography is of prime importance in deciding the method of treatment.

The Formation of an Acetabular Roof. Dr. Gustav Hauberg (Germany) discussed his results with 330 early acetabular-roof arthroplasties. He said that early shelf arthroplasty, after a period of maintenance of previous reduction, is undoubtedly a step forward in the treatment of a dislocated hip joint. The excellent results obtained by Dr. Hauberg were due, he believes, to stimulation of the acetabular growth centers.

Spontaneous Straightening of the Femoral Neck Following Adduction Osteotomy in Congenital Dysplasia of the Hip. Prof. Hans Mau (Germany) said that the purpose of adduction osteotomy is to obtain a deep position of the femoral head in the acetabulum to decrease pressure on the lateral acetabular roof, thus permitting better development. He also discussed the mechanical principles of adduction osteotomy. In summary, he said that recurrence of coxa valga may be anticipated when there is reduced efficiency of the abductors, especially in the presence of a marked shallow acetabulum with subluxation and increased antetorsion. At present, he is not able to predict, with certainty, whether straightening will occur after adduction osteotomy.

The Development of the Hip Joint after Intertrochanteric Osteotomy. Dr. W. Mohing (Germany) was favorably impressed by the results he obtained after adduction osteotomy. He also performed derotation osteotomy in selected cases.

Indications, Technique, and Results of the Leveuf Operation in Congenital Dislocation of the Hip. Prof. K. Idelberger (Germany) described the technique and discussed the results of the Leveuf operation—acetabuloplasty and derotation osteotomy. He considered this operation to be the last resort in the early treatment of dislocation and said he preferred a two-stage operation: first, correction of antetorsion and, second, formation of a new acetabulum.

The Handling of the Operation and Secondary Treatment of the Dysplastic Hip. Prof. Gerhard Exner (Germany) believes that three to five years is the optimum age for operation. He prefers the two-stage procedure consisting in intertrochanteric osteotomy and shelf operation. He found subtrochanteric osteotomy to be unsatisfactory.

A Special Treatment for Congenital Dysplasia of the Hip. Mr. F. C. Dwyer (Great Britain) expressed the conviction that protection of the hip for a long period of time was imperative and that to allow weight-bearing in the presence of an osteochondritic femoral head is to court disaster. He discussed the role played by a caliper non-weight-bearing splint in achieving prolonged protection.

Basic Factors to be Considered in the Development of Congenital Dysplasia of the Hip. Mr. E. W. Somerville (Great Britain) discussed the etiology of dislocation and said that all the pathological changes could be secondary to a primary relaxation of the capsule, predicated on a maternal hormonal influence or other such similar stimulus. He speculated that in these circumstances, if the hips of all children were protected in the first few weeks of life, it would not only abolish instability of the hip, but also greatly reduce osteo-arthritis in later life.

The Treatment of Congenital Dislocation of the Hip. Dr. Carlo Marino-Zucco (Italy) surveyed 748 cases of congenital dislocation of the hip and found improved results after prolonged abduction, which followed manual reduction. Delayed weight-bearing—in some instances walking was not permitted for two years—was a prominent feature of this method.

Tuesday, September 6

Embryological Dislocation of the Hip. Dr. V. Pietrogrande, Dr. G. Monticelli, and Dr. Carlo Marino-Zucco (Italy).

Special Roentgenographic Studies for Differentiation between Acetabular Dysplasia and Congenital Dislocation. Prof. Isaharu Miki (Japan) found, after a study of 29,927 roentgenograms of new-born infants, that the Ortolani sign was not always reliable and that the Hilgenreiner criteria were not dependable in some instances. He showed several roentgenograms where spontaneous reduction occurred and some where there was postnatal dislocation. Prof. Miki said that there is a likelihood of error in measurement when roentgenograms are made with the patient in the supine position and that he preferred a weight-bearing position. He further said that his principal criteria for diagnosis were fluoroscopic.

How Acetabular Dysplasia Is Related with the Occurrence of Congenital Dislocation of the Hip. Dr. Saburo Iino (Japan) defined the criteria of Hilgenreiner according to age and sex. From birth to three months of age, it is 30 degrees for girls and 34 degrees for boys; it gradually decreases to 25 and 30 degrees, respectively, by the age of nine to twelve months. He presented evidence that malnutrition or undernourishment leads to increasing numbers of dysplasia and dislocation, the latter being most prevalent when the infant reached about six months of age. There was a sharp drop in frequency after nine months of age; Dr. Iino believes this to be due to spontaneous healing. He showed that dysplasia rarely progresses to dislocation, but subluxation nearly always does.

Etiology and Treatment of Congenital Dysplasia of the Hip. Mr. H. Walden Fitzgerald (New Zealand) considered the underlying cause of subluxation and dislocation to be, most likely, a neuromuscular imbalance caused by genetic, postural, or some indefinite factor. He said that dislocation is rarely seen at birth without some other gross genetic aberration, such as club-foot, hare-lip, or arthrogryposis. Mr. Fitzgerald has had consistent success without any complications with the following treatment: (1) gradual reduction on a frame, with increasing abduction and internal rotation; (2) derotational osteotomy; and (3) a period in a Batchelor plaster cast.

The Frequency of Congenital Hip Dysplasia and the Effectiveness of Early Treatment. Prof. Wiktor Dega (Poland) reported on a survey of 36,000 new-born infants and said that signs of dysplasia were found in 1,331 infants (3.7 per cent) immediately after birth. Of these, fifty-nine infants (4.4 per cent) had dislocation of the hip joint. Thus, the ratio of dislocation of the hip in the new-born infant was 1.6:1,000 (one boy to 3.5 girls). In some infants the Ortolani sign disappeared after the first three days of life. Prof. Dega felt that roentgenograms were valuable only after the infant had reached four months of age; until then, true roentgenographic interpretation was difficult and the choice of treatment was guided by clinical signs. Early treatment was always by progressive abduction: large swaddle, Frejka's pillow, and Ortolani's splint.

Some Considerations about Congenital Dislocation of the Hip, Based on Personal Experience. Prof. Dr. Al Radulescu (Rumania) presented the novel idea of an infectious etiology for the disease, the site being the adductors.

Diagnosis and Treatment of Congenital Dislocation of the Hip in the Newborn. Dr. Sophus von Rosen (Sweden) gave the incidence of dysplasia during an eight-year period as 0.15 per cent, forty of approximately 24,000 children born in Malmö from 1952 through 1959. Since the disease can be diagnosed at birth (almost all children in Malmö are born in a hospital and are examined by a pediatrician within two days) treatment by positional splint can be started within two or three days. With this early treatment the affected hip joints were stable in the reduced position within a week or two, and the frame was discarded before the infant was three months old. This treatment is so efficient and innocuous that Dr. von Rosen believes that all dysplasias should be so treated, even though many of them will not develop abnormally. He also believes that the cause of congenital dislocation of the hip may well be a slackness in the soft tissues of the hip joints, combined with a slackness in the pelvic joints, and that this may be hormone-conditioned.

Etiology and Treatment of Congenital Dysplasia of the Hip. Prof. José L. Bado (Uruguay) interpreted the evidence for the etiology of the disease as indicating a muscular defect consisting of, particularly, immaturity of the fibers of the adduction muscles. From a clinical point of view, of great value in early diagnosis is the most constant, earliest, and easiest-to-find sign—limitation of abduction. This is always present because it is responsible for the dislocation and its consequence. The author did not recommend open reduction; he advocated obturator neurectomy, adductor myotomy, and Z-tenotomy of the psoas.

Roentgenographic Observations in the Course of Postnatal Spontaneous Evolution of Dysplastic Hips. Prof. Bogdan Brecelj (Jugoslavia) based his observations on the examination of 589 infants, from one day to two years of age, who were from an area where congenital dislocation of the hip is very frequent (30 per cent of the general population). Two hundred and thirty-nine of the infants examined had congenital anomalies of the hip; of these, 149 had dysplasia. The author found, at a two-year follow-up of untreated children, that the dysplasia did not progress to dislocation, but rather to other manifestations of congenital anomalies. He also found some cases of spontaneous reduction of the dislocated hip.

The Prognostic Value of "Le Schema Réductionnel" of Congenital Dislocation of the Hip. Dr. J. Piollet and Dr. M. David (France) presented a classification of long-term results based on both the stability and the difficulty of reduction. Excellent stability associated with absence of difficulty of reduction is considered an excellent result; excellent stability associated with difficult reduction is considered an acceptable result; and poor stability, chiefly associated with difficult reduction, is considered a bad result.

Innominate Osteotomy. An Operation for the Instability of Reduction of Congenital Dislocation and Congenital Subluxation of the Hip. Dr. Robert B. Salter (Canada) performed innominate osteotomy, an operation designed to redirect the entire acetabulum as a unit, on children over eighteen months of age. He believes that the basic abnormality responsible for instability of the hip after reduction of congenital dislocation or congenital subluxation is the abnormal direction which the entire acetabulum faces. The principle of Dr. Salter's operation is to render the reduced hip as stable in the functional position of weight-bearing as it was before operation in the abducted and flexed position.

Rotation of the Acetabular Roof for Treatment of Congenital Dysplasia of the Hip. Dr. Paul A. Pemberton (U.S.A.) described an extra-articular operation for restoration of an adequate acetabular roof by osteotomy of the ilium. In his experience (eighty-one hips in sixty-six patients from one through eleven years of age), this operation has given better-functioning hip joints with fewer complications than previously described operations. Because of the shortened period of treatment, the lowered incidence of complications, and the apparent freedom from risk of redislocation, this procedure might be considered a more conservative method of treatment in the child who has borne weight on the dysplastic hip than the usual procedures of traction, manipulation, and prolonged casting or splinting.

Experimental Aspects of Congenital Dislocation and Congenital Dysplasia of the Hip. Dr. William S. Smith (U.S.A.) performed experimental dislocation of the hip on young dogs and found that progressive acetabular dysplasia was the inevitable consequence, and that capsular stretching could also induce dysplasia. He also placed objects of different shapes and sizes within the acetabulum, and found that the shape of the acetabulum was largely dependent on the functional demand within it. He concluded that from an experimental standpoint, hip dysplasia is more likely a secondary, acquired lesion than a truly congenital one.

Gradual Reduction in the Congenital Dislocation of the Hip in Infancy. Dr. Joseph E. Milgram (U.S.A.) related the treatment he developed to avoid osteochondritis and to promote optimum development of the hip. Where no dislocation has occurred, he uses a foam-rubber diaper to maintain an abduction position. Where dislocation has occurred, he uses a traction cast or, for bilateral disease, bed traction; in this way, he obtains spontaneous or so-called accidental reduction. Traction is maintained for three or more weeks, followed by three months in the original plaster. This is followed by spica splints in which hip flexion-rotation is permitted. The author's series of eighty-one cases showed 79 per cent excellent results and 13.5 per cent good results. Where osteochondritis had occurred, prolonged motion in a non-weight-bearing splint was recommended.

Basic Factors in the Etiology of Congenital Dysplasia of the Hip. Dr. Beckett Howorth (U.S.A.) maintained that congenital dislocation of the hip is not a primary dysplasia of the acetabulum. He said that subluxation or dislocation of the fetal or infant hip is prevented by a strong intact capsule of normal length; elongation or relaxation of the capsule, perhaps originally of hormonal origin, is the primary factor in congenital dysplasia of the hip.

Is Congenital Dysplasia of the Hip a Forerunner of Congenital Dislocation? Dr. H. Relton McCarroll (U.S.A.) believes, on the basis of clinical findings and experience derived from treatment of patients with these congenital abnormalities during the past twenty years, that congenital dysplasia of the hip and congenital dislocation of the hip are primary, distinct clinical entities; primary and distinct because each exists in its own form at the time of birth, and each requires a distinct type of treatment to obtain the most satisfactory result.

Congenital Dislocation in Infants. Dr. Pierre Bertrand and Dr. H. Guias (France) determined their method of treatment primarily by arthrography. In their large series of cases, two-thirds of the patients were treated by open reduction; the remainder, by closed methods. They said that true results must be proved by time, and that re-examination at not less than two years is mandatory for proper evaluation.

Congenital Dysplasia of the Hip. Dr. Alvaro López (Spain) made a comprehensive roentgenographic study of a large number of fetuses, using modifications of the method of Hilgenreiner and Coleman. He also made histological, arteriographic, and arthrographic investigations of anatomical material.

In summary, the various contributors covered the subject of congenital dislocation of the hip, some presenting doctrinaire explanations of etiology and rationale for treatment, others presenting more conservative methods. The entire subject will be published *in extenso* and a more integrated summary, therefore, is not feasible at this time.

Question Two: The Study of Osteogenesis with its Relation to Delayed Union and Pseudarthrosis

Reporter: Dr. Harold B. Boyd (U.S.A.)
Reporters: Dr. J. Judet and Dr. R. Judet (France)
Reporter: Dr. Robert D. Ray (U.S.A.)

Wednesday, September 7

Discussors of Question Two

Diaphyseal Pseudarthrosis. Method of Chutro-Phemister. Dr. Carlos Ottolenghi (Argentina) made a study of the treatment of delayed union and pseudarthrosis by the method described in 1918 by Chutro and in 1931 by Phemister.

The procedure consisted in application of an autogenous graft subperiosteally with metal fixation without resection of the interposed fibrous tissue. Various modifications of the original method were described with emphasis on the preservation of the interposed tissue.

The procedure is indicated in cases of delayed union of long bones and pseudarthroses with displacement and angulation compatible with satisfactory function, in the presence of normally preserved skin in the region, and in the absence of infection. Twenty-five cases were presented in which consolidation occurred in an average of three months.

Pseudarthrosis of the Long Bones. Mr. J. Francis Silva (Ceylon) said that one cannot expect union of bones if motion of the fragments is permitted. In Ceylon, fractures of the long bones are often treated by native practitioners who set the fractures without anesthesia and without immobilizing the joint above and below. The splint consists of bamboo sticks of equal size tied

firmly around the limb; incorporated in the splint is a piece of cloth soaked in herbal oils. Mr. Silva described two patients who had been treated in this fashion; they had come to his hospital because of non-union three and twenty years, respectively, after injury. Both patients were treated successfully by the author.

The Treatment of Diaphyseal Pseudarthrosis. Dr. R. Merle d'Aubigné and Dr. J. Cauchoix (France) presented the results of a series of 814 cases of pseudarthrosis treated between 1945 and 1959. They said that the conclusions of the reporters were in the main confirmed by their own experience, and that the skeletal distribution of the pseudarthroses was comparable. The statistics presented revealed the disastrous role of osteosynthesis as compared with the rarity of failure of union in the absence of that operation.

Twenty-six per cent of the cases had been complicated by infection at the time of the initial treatment after injury. The higher proportion of infection in the series was owing to lack of antibiotics and unfavorable surgical conditions—the situation in France between 1944 and 1945.

There were 978 operations on 814 patients; eighteen patients were lost to follow-up, and there were seventeen amputations (explained by the higher proportion of infected pseudarthroses). The final score was bone union in 94 per cent of the cases.

The study of results by regions seemed to bring out several interesting points:

1. The incidence of failure at the first operation was 17 per cent, almost all from infection. The frequency and severity of the reinfections at the site of prior infection in the pseudarthrosis led the authors to abandon the use of the intramedullary nail in these infected cases and, in its place, to employ an autogenous graft applied across a part not involved in the suppuration. Much better results were obtained after this change was made;

2. The remarkable higher proportion of success gained through a particular operation on the humerus—90 per cent. They believe that the better percentage is owing to the systematic association of a graft with the intramedullary nail;

3. The results obtained by open operation. Various methods of osteosynthesis including, especially, those involving the use of external devices to produce compression yielded too many failures. Nor had the use of the intramedullary nail increased the proportion of successes. The use of the fitted graft employed early in the series was characterized by the high proportion of failures, especially when employed in fractures of the tibia and on the medial face of that bone, because of the predisposition to infection at that site.

After more than ten years of trial, two methods were decided on: the onlay graft with medullary nailing and the onlay graft without medullary nailing. The authors prefer the onlay autogenous graft protected by an intramedullary nail. This method was employed in 327 cases, including the cases in the beginning of the series with poor prognosis; that is, infected fractures and those which had been treated with too small a nail. The authors now believe that it is necessary to reserve the method for cases free of infection. Also, since the tools to ream the medullary canal are now available, and they know it is necessary to use a nail so large that its introduction is carried out against hard friction, they have experienced practically no failures.

The elimination of hip or shoulder plaster spicas, through the rigid fixation imparted by the intramedullary nail, is a great step forward. The authors favor using the nail not only for firm fixation but because it results in quicker bone union.

As to infection, although it does not always prevent bone union it renders the occurrence of the union more contingent. There was 3 per cent of failure of union in the aseptic cases, whereas the incidence of failure among the patients having had a septic episode was 10 per cent.

Dr. Merle d'Aubigné and Dr. Cauchoix concluded that: (1) The prime necessity for union in pseudarthrosis is immobilization with contact of the fragment ends. Such immobilization must be durable enough to protect the tardiest consolidation. This can be realized only through the intramedullary nail, very large in caliber and introduced after reaming the medullary cavity; (2) The autogenous graft accelerates this consolidation; (3) In favorable cases, such as the radius alone and when the nail is contra-indicated, the autogenous graft, screwed in place, may be sufficient, if protected by an external splint; and (4) The role of other factors, particularly that of compression, is extremely debatable: there is nothing in the facts observed to permit affirming its worth in diaphyseal pseudarthrosis.

The Treatment of Pseudarthrosis of the Leg by the Inter-Tibio-Fibular Graft. Dr. J. D. Ramadier (France) reported that infected pseudarthroses of the tibia have been successfully treated by the insertion of a bone graft bridging the interval between the two tibial fragments and the fibula, thus providing support to the tibial fragments, as well as an additional source of blood supply. The graft is inserted through a lateral or posterolateral approach at a point removed from the scar or sinus. (The work was done on the Service of Dr. Merle d'Aubigné.)

About thirty cases formed the basis of the report, which stated that infection became less of a problem and that union was regularly obtained.

Experiences with the Use of Bone Grafts Preserved in Cialit in Over 800 Operations. Prof. Dr. E. Güntz (Germany) said that he had used homogenous-bone grafts preserved in cialit in various orthopaedic operations almost exclusively during the past seven years. Of the 833 cases in which this type of graft was used, there were twenty-four failures of union (2.88 per cent); in all others, the grafts united. Cialit is an organic mercury compound which is light-stable, of almost unlimited durability, and has a bactericidal and fungicidal effect.

The grafts are preserved in cialit in glass bottles at room temperature. The author found the grafts implantable up to three and three-quarters years; grafts preserved between three and forty weeks seem to be most suitable.

Experiences with the Preservation of Bone in Palacos. Prof. Dr. K. Idelberger (Germany) described bone grafts immersed in liquid palacos, a synthetic material similar to plexiglas, in a sterile plexiglas container. To prevent pore formation as the palacos hardens, the whole container is immersed in cold water. Hardening to the consistency of amber takes places in ten minutes; the graft remains clearly visible through the transparent synthetic. The night before the operation, the graft, encased in palacos, is placed in zephirol or permanganate. It is freed from its palacos encasement by one stroke of a chisel. Grafts preserved in this way were used in twenty instances; the grafts healed by primary intention in each instance.

The Treatment of Pseudarthrosis. Prof. Dr. Gerhard B. G. Küntscher (Germany) outlined his treatment of pseudarthrosis by intramedullary nailing. If the method is to succeed the nail must be thick enough and must be so placed as to produce absolute immobilization at the site of the pseudarthrosis. This may require reaming of the marrow cavity if it is too narrow to accommodate a nail of the necessary thickness. For reaming he uses flexible reamers which are made to follow the medullary cavity by a guide wire, which also directs the nail. The work is done through a one-inch incision. Illustrative cases were presented by lantern slides showing union taking place in pseudarthroses of the radius, ulna, humerus, tibia, and femur after reaming and insertion of the Küntscher rod along the guide wire.

The Use of Homoplastic and Autoplastic Bone Transplants. Dr. Max Lange (Germany) reported the results of experience based on 788 operations for pseudarthrosis of the long bones, performed from 1945 through 1959, with follow-up studies of 549 patients. He found that the combined use of the autogenous graft of the onlay type and the intramedullary nail inserted after reaming gave the best results. Intramedullary nailing without preliminary reaming has been abandoned, and results with autogenous grafting alone had been less favorable than those when combined graft and intramedullary nailing after reaming were used. Autogenous grafts were used when a high osteogenic potency was required of the graft, as in bone defects and extensive scar. Homogenous grafts were used in highly receptive areas.

The Use of Bone Grafts in Malposition and Non-union of Fractures of Shafts of Long Bones. Mr. R. G. Taylor (England) presented experiences, from 1950 through 1955, in the Accident Service in Oxford, England. Of a total of 16,700 fractures treated, the shafts of the long bones required grafting operations seventy-two times in only sixty-eight patients. Of these operations, fifty-one were for fibrous union and twenty-one were for malposition. Among the bones with non-union there were twenty-four tibiae, five femora, sixteen radii, and six ulnae. Autogenous grafts alone were employed, tibial cortical bone being used in all instances except where gaps had to be filled with cancellous bone. Cortical bone was used with four screws; it thus acted as a good bone plate and, in addition, supplied osteogenic material. The author said that the roentgenographic evidence in support of the latter claim was entirely convincing; of seventy-two grafts, seventy unions took place. "Early bone grafting [cortical autogenous graft fixed with four screws] is often the best method of internal fixation of shafts of long bones in which reduction or maintenance of reduction by closed methods has failed." Bone-grafting was reserved for fibrous union and where malposition due to instability at the fracture site or unavoidable delay in reduction made it necessary to employ internal fixation. The types of grafting were: first, inlay and onlay; second, onlay; third, dual onlay; and fourth, cancellous chips to fill gaps.

Hypervascular, Demineralized Bone Grafts with Added Live Osteoblasts. Dr. Antonio Hernandez-Ros (Spain) reviewed the principles of active osteogenesis. Citing Ham and Harris, he indicated that only those grafts survive which show a proliferation of the transplanted

cell in the area of transplantation. In the ordinary grafts, only the most superficial cells survive; the other cells are destroyed because of local ischemia. To overcome bone density and the obstacles to vascularization, the use of demineralized and vascularized bone is most effective.

The author suggested a method of treatment that consists in preliminary preparation of a graft in the region of the anteromedial side of the tibia. With the patient under general anesthesia and with control by a tourniquet, the periosteum and thin area of the cortical bone are elevated with a thin osteotome in a site which would correspond to the future transplantation graft. The skin is then resutured. From eight to ten weeks later, the previously prepared bone is removed with its periosteum and some of the surrounding tissue and the elevated skin is again closed. The graft taken from the area is placed into the area of pseudarthrosis or into any other area where the bone graft is necessary for treatment of pseudarthrosis or any other bone fusion.

Recent Views on Osteogenesis: An Experimental Study. The Vascular Role of Reparative Osteogenesis. Prof. J. Trueta (England) discussed the healing process following fracture of bone, based on experimental work with rabbits done by himself and Dr. A. X. Cavadias, of Greece, from 1956 through 1957. They concluded that periosteal vascular penetration from the surrounding tissues was the deciding factor in bone healing. The vascular wall took a most active part in generating the new bone beyond the preliminary state of calcified cartilage. The maturing cartilage cells, or their surrounding matrix, seemed to elaborate the substance or substances which attracted the vessels. Any disturbance in healing was followed by the production of an exuberant surrounding hypervascular callus, such as seen when a heterograft is used. This hypervascularity is far greater in a heterograft than in an autograft, although the vessels do not enter the heterograft. When failure of union was occurring across the fracture gap, the vessels crossing the gap failed to remain permeable because of lack of protection or because of soft-tissue interposition, preventing anastomosis across the gap from the two sides. The nutrient artery was always found to have been interrupted by the fracture, being shut off from the distal fragment by the fracture and from the proximal fragment by thrombosis. The periosteum near the fracture line was lifted and this deprived the cortical fragment ends of living bone, causing them to act as autogenous grafts to which blood vessels promptly flowed from the surrounding soft parts. Rapidly maturing cartilage cells appeared early under the ends of the bone fragments. It was not clear whether these cells were formed because of relatively poor nutritional conditions or from intermittent pressure from muscle contraction. At the moment the cartilage cells began to appear, the vascular invasion became directed toward the areas of cartilage.

Osteogenesis and Pseudarthrosis. Dr. Boni-Pietrogrande (Italy), on behalf of Dr. Marino-Zucco (Italy) and in collaboration with Dr. Monticelli-Boni (Italy), presented a general review of the accredited body of knowledge upon which the outlines of the various phases of the healing process and its deviations are based. The known causes of aberrant healing were defined, and the general principles underlying the surgical and non-operative treatment were thoroughly discussed, with special reference to "retarded consolidation", "retarded pseudarthrosis", and pseudarthrosis. For pseudarthrosis surgery alone was recommended; this included excision of interposed sclerotic tissue, reopening the medullary canal, matching fragments, internal fixation, and autogenous grafts. The bone callus in pathological fracture had been found to vary with the quantity and quality of the interposed diseased tissue, apparently having peculiarities characteristic of each type of neoplasm and the amount of neoplastic tissue present at the fracture.

Biomechanical Principles in the Treatment of Delayed Union and Pseudarthrosis. Dr. Maurice F. Muller (Switzerland) pointed out that Pauwels of Aix la Chapelle showed that in pseudarthrosis of the neck of the femur, an intertrochanteric osteotomy with fixation in abduction commonly results in bone union at the pseudarthrosis which may occur in a matter of weeks. Through the change in alignment, whereby the plane of the fracture becomes horizontal, shear is eliminated and compression is exerted at the site of fracture. Heavy work may be resumed seven months after the intervention.

The author said that Danis of Belgium has shown that the tissues interposed between fragments in pseudarthrosis should not be excised, because under the influence of axial compression (which he applies through the use of his coapters) ossification develops within them; the more the pressure, the more rapidly the change to bone occurs. Pseudarthrosis of the humerus may heal in ten weeks. Küntscher of Germany showed a number of pseudarthroses, such as may occur in the femur, which healed without difficulty after reaming of the medullary cavity and introduction of his nail. Judet of France recently presented a series of infected and non-infected pseudarthroses, which healed solely as a result of externally applied compression. Here again, there was rapid metaplasia of the tissues interposed between fragments at the site of the pseudarthrosis.

In vitro studies showed that fibroblasts may be transformed into bone cells or cartilage cells and, under proper osmotic conditions, may give rise to bone if oxygen, phosphorus, and calcium ions are present.

If it is really possible to produce rapid ossification of tissue interposed between fragments of bone by changing certain mechanical factors, why, when we try to heal pseudarthroses, do we introduce grafts which require three to nine months to become revitalized? Firm fixation may be secured by the device of Danis (the plate is applied with the fragments pressed together) and that of Küntscher (the medullary cavity is reamed to permit the use of an intramedullary nail large enough to give absolute fixation when driven across the area of the pseudarthrosis). Fixation of the fragments is so firm that immediate mobilization of the joints adjacent to the pseudarthrosis is permitted. "Why apply a plaster splint which immobilizes these joints and which may cause irreparable trophic disturbances?", Dr. Muller asked. He endeavored to improve his results by the application of internal fixation with the pseudarthrosis under compression. To this end he employed the Danis plate or the Küntscher nail. When the local mechanical conditions as described were achieved, he noted rapid ossification of the interposed tissue. Even when it was necessary to employ a graft, in addition to the firm fixation, he had his patients exercise the joints of the involved limb not later than the day after operation. He has not used a plaster splint since the adoption of this technique.

To apply the plate with the pseudarthrosis under compression, it is fixed, for example, to the distal fragment and a compressor is then screwed temporarily to the other fragment. By a special jointed key a greater compression is obtained; the plate is then screwed in place and the compressor is removed.

When infection is present in the pseudarthrosis, Dr. Muller believes that complete immobilization represents the treatment of choice, and plates can be used for this purpose.

In conclusion, he believes that in the great majority of pseudarthroses the tissue interposed between fragments should not be excised inasmuch as it usually contains polyvalent mesenchymal cells which transform into osteoblasts and osteocytes. Plates applied under pressure are particularly indicated in fractures of the upper extremity, and Küntscher nails inserted along the medullary cavity after reaming of the cavity in the fragments are particularly indicated in the lower extremity. As a general rule, they permit one to obtain fixation sufficiently firm to omit all plaster splints after operation, to shorten the period of hospitalization, and to keep disability to a minimum.

The Contact-Compression Factor in Osteogenesis. Dr. G. W. N. Eggers (U.S.A.), Dr. T. O. Shindler (U.S.A.), and Dr. C. M. Pomerat (U.S.A.) again emphasized the concept of contact-compression which they have, for a long time, stressed as a factor of primary importance in the healing of fractures. In contrast, Dr. Eggers indicated the deterrent effect of shear and distraction. Contact-compression is most effectively imparted by the tonic and voluntary tonus of the muscles; the rigid plate, conversely, may hold the fragments apart, thus preventing the operation of these important beneficial factors. In experimental support of this thesis a bone flap, 2,500 micra wide, was made in the parietal bone of adult rats with a saw 150 micra thick. On one side of the flap, contact under pressure was made with the rest of the skull through rubber bands stretched between the flap and the fixed portion of the skull. On the opposite side of the flap, contact and compression were lacking between the flap and the adjacent bone. Bone union always took place promptly on the contact-compression side of each flap; healing was always lacking on the opposite side where distraction of the adjacent bone surfaces was present.

The Study of Osteogenesis and Its Relation to Delayed Union and Pseudarthrosis. Dr. Edward L. Compere (U.S.A.) stressed the importance in fracture healing of preservation of the blood clot about the fragment ends, of accurate reduction, and of physiological compression between fracture surfaces. Whenever possible, the fracture should be reduced by the closed method and reduction maintained by external fixation. Thus, the blood clot is preserved and physiological compression takes place at the fracture site through the tonus of the muscles. Open reduction should be reserved for fractures which cannot be reduced and maintained by closed methods. "The addition of large supplements of vitamin D" or of calcium "to a well balanced diet is of no value in the prevention of delayed union or pseudarthrosis". When open reduction is necessary and reduction cannot be maintained without internal fixation, it should be by some method which will permit a continuous compression between the fracture surfaces as the usual absorption of bone takes place. This can be accomplished by an intramedullary rod or a slotted plate, such as devised by Eggers. Autogenous grafts, preferably chip and sliver grafts obtained from the adjacent fracture fragments, are placed across the fracture lines.

A Case of Pseudarthrosis of the Upper Part of the Tibia Treated by Implantation of the Fibula. Dr. Alexander Manzoni (England) presented a case of successful healing of an old pseudarthrosis through the implantation of the fibula across the fracture gap after division of the fibular shaft just below the fibular head. There was a seven year follow-up.

Thursday, September 8

Symposium: Teaching and Training in Orthopaedic Surgery and Traumatology and the Organization of Hospital Services

Moderator: Sir Harry Platt (Great Britain)
Reporter: Dr. R. Merle d'Aubigné (France)
Reporter: Dr. M. Hackenbroch (Germany)
Reporter: Dr. Carlo Marino-Zucco (Italy)
Reporter: Dr. Harold A. Sofield (U.S.A.)

Teaching and Organization of Orthopaedic Surgery and Traumatology. Dr. R. Merle d'Aubigné (France) believes that traumatic as well as non-traumatic orthopaedic conditions should receive treatment by specialists, except in areas where a scattered population and lack of a large hospital do not favor development of large-scale orthopaedic services. The teaching of general practitioners and surgeons is the responsibility of the large medical centers affiliated with medical schools. Those who are going to practice in places remote from well organized hospitals should get a year or two of training in orthopaedics. By doing so they will learn how to treat simple cases with confidence and will select patients to be sent to the more specialized centers.

The author regrets that in his country the specialty of orthopaedic surgery is not yet officially recognized for teaching and there are no official examinations. Training is done by individual groups and no diploma is available for specialists. The younger general surgeons do not object to the identification of orthopaedic surgery as such. More interest in the organization of orthopaedic units and the care of accident cases is being shown by public health agencies.

Instruction and Training at the University of Rome. Dr. Carlo Marino-Zucco (Italy) described the facilities at the University of Rome for the instruction of medical students and for postgraduate work in orthopaedics. The author believes that those doctors who are entering general practice should be more conversant with the problems of orthopaedic disease and of traumatology since, in the modern state, the mechanization of industry and automobiles have made such problems increase. Furthermore, with the social-security system, as practiced in Italy, orthopaedic problems come to the attention of the general practitioner first; an understanding of orthopaedics is therefore necessary for better rehabilitation of the patient.

Teaching and Training in Orthopaedic Surgery and Traumatology and the Organization of Hospital Services. Dr. Harold A. Sofield (U.S.A.) outlined the status of teaching and training in orthopaedic surgery in the United States. The time allotted for teaching this specialty in the medical schools is inadequate, but there is some exposure to the principles in this field. The American Board of Orthopaedic Surgery, which is composed of representatives from The American Orthopaedic Association, The American Academy of Orthopaedic Surgeons, and the Section on Orthopaedic Surgery of the American Medical Association, requires the following minimum period of training prior to the formal examinations: (1) graduation from an approved medical school; (2) at least one year of internship; (3) one year in general surgery or an extra year in orthopaedic surgery or research; (4) three years in an approved residency in orthopaedic surgery, which should give an adequate training in the basic sciences, adult and children's orthopaedics, and traumatology; and (5) the first examination may be taken after the training just mentioned, but the final examination must wait until the minimum of six years has elapsed since the start of training (see 3).

Final certification by the Board carries no governmental authority, although it has been helpful in obtaining positions on hospital staffs and as an aid to establishing competency by some state employment bureaus.

Discussors of Symposium

Orthopaedic and Fracture Service at the Dunedin Hospital and Otago Medical School. Mr. H. Walden Fitzgerald (New Zealand) described the orthopaedic and fracture service of the Dunedin Hospital and Otago Medical School in New Zealand. The training program follows basically the principles of the Scottish school with emphasis on clinical teaching and apprenticeship. In 1936, following the practice in Great Britain, the orthopaedic service took over the treatment of all fractures and allied injuries. Adequate time is allotted to teaching the medical

students since orthopaedics is regarded in New Zealand as one of the two main divisions of general surgery and is not split off as a subspecialty. Orthopaedics is taught in all its phases under the definition of Sir Robert Jones: "The treatment by manipulation, operation, re-education, and rehabilitation, of the injuries and disorders of the locomotive system".

Teaching and Training at the New York Orthopaedic Hospital Over a Period of Thirty-seven Years. Dr. Alan DeForest Smith (U.S.A.) outlined the graduate training program in orthopaedics and traumatology at the New York Orthopaedic Hospital (the orthopaedic component of the Presbyterian Hospital and College of Physicians and Surgeons, Columbia University). This program conforms basically with the requirements of the American Board of Orthopaedic Surgery. Excellent facilities are available for study, surgery, and research. Each of the trainees reaching the final required year of his three-year training has the responsibility of chief resident surgeon for his appropriate share of that year. One of the residents may be invited to take another year of training with greater responsibility. Fellowships are available for those interested in research and the study of orthopaedic surgery.

Teaching and Training in Orthopaedic Surgery and Traumatology and the Organization of Hospital Services. Dr. Lorenz Böhler (Austria) believes that the teaching of both surgery of trauma and efficient organization in the handling of accidents is neglected in many hospitals and medical schools. Because accident cases may involve many parts of the body, a surgeon treating such conditions must be able to do procedures other than just bone and joint surgery, such as tracheostomy, and he must understand the principles in the care of the chest and abdominal injuries. He must be trained and capable of handling his patients so that time and effort are not dissipated by too many consultations with roentgenologists, physiatrists, and internists.

To improve the treatment in cases involving trauma, the author believes that the specialty of traumatology must become independent. In hospitals of 100 or more surgical beds a separate department for orthopaedic surgery and traumatology should be organized. This will be efficient only if the orthopaedic and traumatology department has its own wards, operating rooms, x-ray room, and trained personnel. In large cities entire hospitals can often be organized to give the best possible service.

Insofar as the staff is concerned, the author recommends at least two years of training in orthopaedics and traumatology for the chief in this specialty in the smaller hospitals, and the full periods of training for the larger centers.

A plea is made for all the medical faculties of the world to organize clinics in this specialty properly and to examine and license well trained surgeons in the field of orthopaedics and traumatology.

Proposal for the Appointment of an International Committee for the Standardization of Orthopaedic Terminology and Classification of Orthopaedic Diseases. Dr. S. Teneff (Italy) proposed the appointment of an international committee for the standardization of terminology and classification of diseases encountered in orthopaedic surgery and practice.

INDIVIDUAL COMMUNICATIONS

Treatment of Chronic Osteomyelitis of the Limbs. Dr. José Valls, Dr. E. Brenner, and Dr. A. M. Segers (Argentina) found that frequently the treatment of chronic osteomyelitis by antibiotics was ineffective. The sclerosed bone and the surrounding scar tissue prevent contact with the antibiotic substances and the organisms. The arterial circulation of the diseased bone is poor and the sclerosis of the diseased one, in addition to edema of the Haversian canals, impedes the circulation of the Haversian system. The bacteria frequently produce emboli which obliterate the arterioles and capillaries. The combination of antibiotic therapy and surgery gives the best results from the authors' point of view.

The method employed is thorough débridement, curettage, and sequestrectomy. The cavity is filled with bone chips, autogenous bone preferred. The bone chips are mixed with the specific antibiotic, the latter determined by culture, and packed firmly into the cavity. The success of the method depends on adequate skin coverage. Pedicle flaps are preferred but, in the experience of the authors, a rotation of local flaps has proved satisfactory. Local flaps are frequently, in fact usually, supplied by inadequate circulation produced by scarring, infection, and capillary and arterial emboli. Gross flaps are therefore taken from the opposite limb in the male, and in the female from the thigh. In one instance a tube flap from the abdominal area was used and brought to the osteomyelitis site by way of the undersurface of the forearm. The donor sites are covered by skin grafts.

Twenty patients were treated by the authors during the past three years; the tibia was involved in sixteen patients, the calcaneus in three, and the humerus in one. The etiology of the

twenty cases was: osteomyelitis after fracture, thirteen; hematogenous osteomyelitis, six; and bone necrosis secondary to skin loss, one. The follow-up in three patients was from zero to six months; in two, from seven to twelve months; in four, from thirteen to eighteen months; in five, from nineteen to twenty-four months; in two, from twenty-five to thirty months; and in four, from thirty-one to thirty-six months. Seventeen patients had excellent results, two had very good results, and one had a fair result.

Primary Chronic Osteomyelitis in the Beginning. Dr. Herbert Gardemin (Germany) said that in chronic infection of the joints in childhood, the onset often manifests itself with non-characteristic complaints and minimum findings. The disease affects the epiphyseal and metaphyseal regions of bone and is characterized by slow development. Roentgenograms are negative; only in the later course of the disease, or after an asymptomatic period which may last for several years, do we find definite clinical signs and positive roentgenographic evidence. In later stages there is local tenderness, but rarely symptomatic effusion, in the affected areas. Joint motion is not impaired and roentgenograms show relatively little radiolucency, mostly subcortical in the epiphysis and metaphysis, which may indicate a defect in the continuity of the cortex. If the defect is located in the epiphysis, the latter is occasionally widened. In the early stages single pus cells are encountered and there is a substantial quantity of fibrous tissue penetrated by a great number of blood vessels. The importance of the focus, which can be stopped only with surgical intervention, is that it gradually spreads, forming a bigger focus. It is therefore important that an early diagnosis be made. The initial complaint is diffuse pain, rather than in a localized area. Inflammation, swelling, and edema are not revealed by clinical examination. The sedimentation rate and blood studies are within normal limits. There is only the presence of pressure tenderness in the region of the epiphysis or metaphysis to make one suspicious of a disease process developing in the periosteum of bone. Diagnosis, therefore, must be based on the following roentgenographic signs: (1) roughness of the cortex; (2) thickening of the periosteum; (3) widening of the epiphysis; and (4) areas of osteoporosis located subcortically in the lateral or medial regions of the epiphysis. Operative intervention is necessary.

Septic Arthritis of the Hip in Infants. Mr. Denys Wainwright (Great Britain) presented observations based on a study of sixty-nine cases of septic arthritis of the hip, thirty-six of which were in children under two years of age and twelve in infants less than six weeks old.

The blood supply of the femoral head in infants was discussed in relationship to septic arthritis and it was pointed out that failure to recognize the infection early may lead to total destruction of the femoral head and neck with upward displacement of the femur. The physical signs of a septic hip in infancy may be difficult to detect, but if the orthopaedist has an awareness of its possibility, it will not be overlooked. As soon as the diagnosis is established, a broad-spectrum antibiotic should be administered until the organism and its sensitivities are established. When indicated, early arthrotomy with immobilization of the extremity in abduction was advised to prevent pathological dislocation.

The author described various approaches to the old healed cases with pathological dislocation and destruction of the head of the femur. A weight-relieving caliper brace, bifurcation osteotomy, and epiphyseal transplant (proximal end of tibia) were methods that had been employed. In older children arthrodesis was the favored treatment but in four patients massive shelf operation and in two patients pelvic support osteotomy were reported to have given satisfactory results.

Injuries by Rotation in the Upper Limbs. Prof. José Luis Bado (Uruguay) discussed the experience gained after fifteen years of treating more than 4,000 fractures of the upper extremities of adults and children. He emphasized the importance of the directional force in creating fractures, stating that the frequency of injuries by internal rotation is very high at the shoulder and at the elbow. Contrarily, external rotation injuries are much more frequent in the forearm and the wrist.

Prof. Bado follows the universal dictum: "In childhood, closed reduction is the rule and the prognosis is good. In adults the rule is the open reduction and the prognosis is not so good."

The author treated sixty Monteggia fractures and is of the opinion that rotational forces are important in the etiology. Internal rotation forces (pronation) produce the so-called painful-pull syndrome in children under three years of age, as expressed by dislocation of the radial head; obstetrical injuries of the elbow; isolated anterior dislocation of the radial head; fractures of the neck of the radius; posterior dislocation of the elbow with fracture of the radial shaft; and posterior dislocation of the elbow with fracture of the ulnar shaft. The most important single maneuver in treatment is closed reduction in supination.

Of 500 cases of fractures of the forearm and wrist in both children and adults, internal rota-

tional forces of pronation was the less common factor, probably 10 or 12 per cent. In this pronation group the author classified fractures of both bones of the forearm, greenstick or complete, as fractures of the radius with dorsal dislocation at the distal end of the ulna. At the wrist this force is interpreted as producing fractures of the lower end of the shaft and dorsal dislocation of the ulna. All these injuries were reduced with the closed method and the supination position.

External rotation force (supination) is the most common physiological factor. In this group are: (1) fractures of the forearm—greenstick fractures of one or both bones, isolated fractures of the radius in any of its three segments, fracture of the radius with palmar dislocation of the lower end of the ulna, or complete fracture of both forearm bones; (2) fractures of the wrist—Colles' fracture, epiphyseal separation in children, or palmar dislocation in the lower end of the ulna; and (3) fractures of the elbow—Monteggia's II. These injuries were treated by closed manipulation and the pronation position.

It is Prof. Bado's opinion that the external rotational forces are a common etiological factor for shoulder injuries, producing anterior dislocations. Diametrically opposite to this force is the internal rotation force producing epiphyseal separations or fractures.

A New Concept of the Monteggia Lesion: Its Application to Treatment. Dr. J. A. Nova Monteiro (Brazil).

SPECIAL GUEST PRESENTATIONS

Results of Treatment of Long Tubular Bone Pseudarthroses in the Leningrad Institute for Traumatology and Orthopaedics. Prof. B. S. Balakina (U.S.S.R.) defined the necessary factors for fracture healing: anatomical contact of fragments and participation of surrounding structures. He said that disturbances of the relationship of the surrounding soft tissues and absence of anatomical contact led to pseudarthroses and that treatment was difficult, resulting in from 15 to 28 per cent of failures.

During the period from 1946 through 1959, 245 patients with pseudarthrosis were treated. Forty-two per cent of the pseudarthroses involved the long bones, of which 13 per cent affected the humerus. The reasons for the pseudarthroses were: inadequate immobilization, early weight-bearing, extensive injury to soft tissues, open operations with excessive removal of fragments, and unequal healing of bones in the lower extremity. In 225 patients there was no loss of bone between the fragments; in twenty patients the loss amounted to from two to seven centimeters. The treatment of pseudarthrosis included grafting with autogenous and homogenous bone and metal fixation, singly or in combination; excision of scar; skin plastic operations; and osteotomies of the fibular head. Heterogenous grafts were used infrequently. Autogenous grafts were used most frequently, either as onlay or intramedullary, or in combination. Sliding grafts were also frequently used. Recently, grafting operations have been done in two stages; first, placing the graft subcutaneously into the fat and, second, transplanting the graft into the area of pseudarthrosis. Homogenous, frozen, bank bone was also used. Intraosseous fixation combined with homogenous and autogenous-bone grafts was used in eighty-seven patients. Bone chips and inlay grafts were used for the combined treatment. Functional postoperative treatment with prolonged immobilization was followed.

Delayed results of union from one to ten years were observed in 167 patients (68.2 per cent). In fifty-nine patients, the results of the treatment were excellent; in fifty-three, good; in twenty-seven, satisfactory; and in twenty-eight, bad.

The best results were obtained with the Klimov-Vorontsov metallic plate combined with bone grafts. Pseudarthroses were found most often in the humerus. The author emphasized the importance of immobilization of fragments, the size and immobility of the graft, and proper functional postoperative treatment.

On Certain Problems of Bone-Grafting in Children. Prof. M. L. Dmitrief (U.S.S.R.) discussed three problems involving bone-grafting in children. The first problem concerned the use of metal intramedullary and plate fixation in fractures of long bones. This was well investigated by the author and by a number of physicians in other clinics and proved to be inapplicable. Conservative and functional treatment is ordinarily used and, in cases of operations, supplemented by heterogenous-bone grafts.

The second problem referred to large bone defects after osteomyelitis or other afflictions. This was treated by transplantation of the fibula into the tibial defect by mobilization of the fibula, without interruption of its blood supply.

The third problem presented an attempt of physiological bone replacement for regeneration of bone in bone defects due to osteoblastoclastoma. The cavities are filled with "osteoblastic" tissue obtained from the metaphysis of the patient's normal tibia, which is drilled from eight to

ten days preceding the transplantation. The author's experiments indicated that drilling of the normal metaphysis induces the formation of a large amount of osteoblastic tissue which, in ten days, undergoes one-half of the usual osteogenic cycle. Transplantation of this bone ten days after drilling makes it ready for the final phase of ossification. A series of good results thus obtained was reported.

A Biological Method of Treatment of Nerve Stumps in Amputations. PROF. I. G. ISAAKYAN (U.S.S.R.) said that the accepted methods of amputations and reamputations are not free from multiple postoperative complications, especially pain, which require further operations. The problem of severe postoperative pain, especially in the lower extremity, was solved by the author's method. With the patient under spinal anesthesia, anterior and posterior skin flaps were made, the neuromuscular bundles were dissected, the vessels ligated, and the nerves isolated. Spinal fluid, which is obtained in the process of spinal anesthesia and saved for the treatment of nerve stumps, was injected into the perineurium of each divided nerve branch.

In a series of 300 amputations, complete elimination of postoperative pain was obtained. The method is based on results obtained in experiments on dogs, which showed that injections of a dye into the cerebrospinal system produced spreading of this dye out into the peripheral-nerve trunks of the extremities. This indicated that normal function, including transmission of pain, is possible only in the presence of spinal fluid. The usual operative procedures of amputation disturb the physiology of the divided nerve trunks and this is restored by injection of the spinal fluid.

The Use of Residual Functional Possibilities for Creation of New Occupations (Professions) in Orthopaedic Patients. ASST. PROF. A. S. LANTSETOVE (U.S.S.R.) stated that the problem of rehabilitation in patients with varied physical defects occupies an important place in orthopaedics and traumatology.

He said that broad measures are undertaken in the Soviet Union to accomplish rehabilitation. A large network of state professional schools; permanent, active courses in industrial plants; special high schools of technical and agricultural training; rational trade induction and adaptation of invalids to work; and broadening of the possibilities of entrance into colleges helped, to a certain extent, to solve this problem.

The Institute of Rehabilitation investigates the work capacity and rehabilitation of invalids. There is a department of rational work structure and work instruction which cooperates with the clinical division and permits creation of work specialization for invalids at the end of their treatment.

In the past few years, 200 invalids, mostly youngsters, were rehabilitated and became independent of children's homes and other places of confinement.

On Some Problems of Bone-Grafting for Loss of Length in Long Bones. DR. L. CHOULOUTKO (U.S.S.R.) stressed the importance of bone-grafting in orthopaedic surgery, especially in loss of length after resections of pseudarthroses. The problem of successful bone-grafting is still present, especially in special cases of suppuration or resorption of the graft.

Certain factors were emphasized in considering the problem: (1) metabolic changes, which indicated functional disturbances of the liver; and (2) changes in the chemical contents of calcium and phosphorus in the bone in the area of the pseudarthrosis, which were similar to changes in the graft taken from normal areas of the skeleton. These are indications that pseudarthrosis is not a local manifestation, but a reflection of the general status of the patient.

The author proposed a method of treatment consisting in proper gradation of the size of the bone graft according to the receptor area, with avoidance of periosteal stripping and inclusion of thin layers of cambial bone; proper fixation of the graft; proper prolonged immobilization; antibiotic postoperative treatment; and general preoperative and postoperative treatment of the patient.

INDIVIDUAL COMMUNICATIONS (*CONTINUED*)

Friday, September 9

A New Method of Surgical Bone Fixation. DR. ROBERT SOEUR (Belgium) described a new method of bone fixation and said it can be used in various conditions of the long bones involving the diaphyses or the epiphyses. Twin Kirshner rods, two millimeters thick, and stainless-steel wire, 0.8 millimeter in diameter, are used.

The method consists in the application of two long rods to the opposite side of a bone, with fixation by two double wires which pierce transversely (through drilled tunnels) the bone above and below the fracture and hold the rods firmly applied to the bone.

In spiral fractures, the rods are placed extraperiosteally; in fractures with angulation, com-

pression can be obtained; and in comminuted fractures, four rods are used. In fractures of the epiphyses, including T fractures, this method is more efficient than insertion of screws and bolts; it also permits fixation of bone grafts along spinous processes or in pseudarthrosis of long bones. In arthrodeses of the knee joint it permits compression by internal fixation.

Implantation of the Fibula in Diaphyseal Bone Defects of the Tibia. Prof. Dr. Domingos Define (Brazil) presented a modification of Hahn's original operation (1884). He stated that his operation differs from other modifications because of the surgical technique and the results obtained.

The features of Dr. Define's operation are: (1) a single incision to expose the tibia and fibula; (2) a single osteotomy of the fibula; and (3) a one-stage operation. The operation was performed on nine children with tibial diaphyseal defects caused by severe hematogenous osteomyelitis. Reconstitution of the tibial diaphysis was obtained in all nine patients; in eight, the fibula was also completely reconstructed.

Epidemiology of Fracture in Old Persons. Dr. Göran C. H. Bauer (Sweden) discussed observations he made in 956 fractures of the neck of the femur and 1,192 fractures of the lower end of the forearm. These were fresh fractures in subjects over twenty years of age. Evaluation of health prior to the fractures of the neck of the femur was possible in 95 per cent of the cases.

Two types of trauma, moderate and severe, were used in classification; the two types were equally common in men, whereas in women, moderate trauma was six times as frequent as severe trauma.

In the series of fractures of the neck of the femur, 41 per cent of the patients were found to suffer from severe disease. In this group, the fractures were caused by idiopathic bone fragility. The author's studies indicated a lag period of from fifteen to seventeen years between the rise of incidence of fractures of the lower end of the forearm and that of fractures of the neck of the femur; this might indicate that symptoms of disturbed skeletal metabolism should be looked for one or two decades prior to the time that fractures of the neck of the femur are likely to occur.

The author concluded by saying that this is an example of a group of patients in whom future research might reveal that fractures in the aged are a symptom of preventable metabolic disease.

High Intertrochanteric Osteotomy and Fixed Bone Graft for Non-union of Fractures of the Neck of the Femur. Dr. Waldemar Rosa dos Santos (Brazil).

The Resection Angulation. Dr. René Charry (France) presented a series of sixty-eight cases in which he had performed resection of the femoral head and neck and basilar abduction angulation osteotomy. Thirty-eight patients had unilateral and fifteen had bilateral involvement. Forty-four of the operations were performed for either primary or secondary degenerative hip disease; in addition, eleven patients had rheumatoid arthritis. The remainder of the operations were for assorted reasons such as intolerance to a plastic prosthesis. In three patients there was partial loss of the angulation and in two there was breakage of the internal fixation. At follow-up approximately 60 per cent of the patients walked with either one or two canes and 40 per cent may ultimately walk without a cane. Approximately 60 per cent could do light work and approximately 30 per cent were able to work full-time.

Adduction Osteotomies in the Treatment of Coxarthrosis. Dr. Maurice E. Muller (Switzerland).

Subtrochanteric Hyperextension Osteotomy. Dr. A. Glauber (Hungary), in the past four years, treated fourteen patients with chronic bilateral congenital dislocation of the hip by subtrochanteric hyperextension osteotomy. In the selection of location and extent of angulation, particular attention was given to improvement of pelvic support and decrease in lumbar (compensatory) lordosis. When considered from the anteroposterior view, the lateral angulation of the proximal fragment should not exceed the lateral pelvic inclination angle, as recommended by Milch. From the lateral view, the hyperextension of the distal portion may be calculated by subtracting the normal pelvic inclination in the standing subject from the measured pelvic inclination or lordosis. Internal support by a metal plate was recommended.

Special Apparatus to Prevent Deformities in Poliomyelitis. Dr. José I. Jarafa (Cuba).

Treatment of the Paralytic Hip Joint. Dr. M. Hackenbroch (Germany) said that although the paralyzed hip is primarily a disturbance of dynamics, secondary organic changes

in the form of the joint can occur during growth. These may result in abnormal position of the limbs and of the trunk. Of particular significance is the paralysis of the abductors. This can occur in flaccid or in spastic paralysis, after transverse sections of the spine, and with dystrophies and meningomyeloceles. If such a disturbance begins in early childhood, coxa valga and antetorsion develop; if before the third year of life, subluxation or complete dislocation occurs. In many cases, a contracture develops.

Attempts to improve the paralytic hip by muscle transplants have not been satisfactory. Even the best—Mustard's transplant of the iliopsoas to the trochanter—does not change the bone abnormalities. Much more effective is the intertrochanteric osteotomy. Although this cannot give ideal results, since it cannot cure the paralysis, it can correct contractures, improve the position of the limbs, and give weak muscles a better chance to work. It can even reduce a subluxation.

Although the contracture is usually in adduction, abduction is sometimes present. It is occasionally wiser not to correct the latter, since patients become so accustomed to it that its correction may cause a loss of power.

Dr. Hackenbroch's experience began with the treatment of long-standing dislocations and arthroses. Originally, he employed the Lorenz bifurcation operation, thrusting the tip of the distal fragment close underneath the femoral head and trying to produce a varus position. As a rule, no internal fixation was necessary, but in some cases it had to be done to prevent excessive varus position. Also, in some cases Schede's modification—the crutch-stick operation—was employed, since it produced less shortening, gave better control of the degree of varus, afforded a longer lever to the abductors, and improved the action of the iliotibial tract.

Complications can be caused by contractures or by subluxations. The former can be corrected by preliminary soft-part operations, but care should be taken not to overdo the correction. For the subluxations, the varus type of osteotomy is indicated. Some cases of complete dislocation, however, require the valgus type. Plastic reconstruction of the acetabular roof (shelf operation) is of little or no value. Dr. M. F. Muller recommends the Chiari pelvic osteotomy for severe cases, but Dr. Hackenbroch prefers the intertrochanteric osteotomy. Occasionally, if the acetabulum is very shallow, an additional shelf procedure may be indicated, or, in some cases, the Mustard or the Löffler button-hole operation. Dr. Hackenbroch's results, although not ideal, have been good in numerous instances.

The Use of the Iliac Crest as a Full-Thickness Graft in Spine Fusion. Dr. Augusto S. Besa (Philippines) reported the use of the following method in spine fusion: a full-thickness section of the iliac crest, with its cortical edges separated at the ends, is placed vertically and implanted on the spinous processes of the adjoining vertebral segments. Much of the work was done in the lumbosacral region, and successful fusion was obtained in the majority of patients.

Congenital Scoliosis. Dr. Walter P. Blount (U.S.A.) discussed scoliosis due to congenital bone deformation. Although certain types of scoliosis caused by one or more hemivertebrae change very little during growth, other types are subject to marked and often sudden increase in curvature of really tremendous nature. The author suggested the use of a Milwaukee brace, close observation of the patient, and fusion of advancing scoliotic curves in any patient showing continued progression of the deformation.

The Significance of Osteochondrosis Vertebralis Juvenilis in Spine Disease. Mr. R. W. Butler (Great Britain) described the development of osteochondrosis through the penetration of disc material into the cartilaginous end-plates of the vertebral bodies and then into the spongiosa or periphery of the vertebral body. The lesion is typically small and multiple at any level, and roentgenographic evidence may not appear until late in the disease. Growth in the height of the vertebra is temporarily arrested, resulting in anterior wedging of the vertebral body. With severe osteochondrosis there is an increase in the anteroposterior diameter of the vertebral bodies; a finding that does not occur in tuberculosis, ankylosing spondylitis, or pyogenic infections. The author also described the late changes of narrowed disc spaces, anterior wedging of the body, increase of the anteroposterior diameter of the vertebral body, hollowing of the upper and lower surfaces of the vertebral body, and premature separation of the epiphyseal ring as classic roentgenographic findings. The relationship of osteochondrosis to early degenerative lesions of the spine was also discussed.

Effects of Controlled Acceleration on Stress-Strain Phenomena in the Intact Vertebral Column. Dr. F. Gaynor Evans (U.S.A.) investigated the effects of acceleration on the vertebral column. A cadaver was placed in a seat belt and shoulder harness and subjected to controlled vertical acceleration of varying magnitude and duration. Data obtained showed that with

the body fully restrained, many accelerations parallel to the long axis of the body produce tensile strain in the cervical region and compressive strain in the thoracic and lumbar regions. With most of the head and chest allowed to move, the strain on the cervical region becomes compressive rather than tensile. No fractures were noted. The importance of head restraint in reducing compression and strain in the cervical region is apparent.

Eosinophilic Granuloma of Bones. Dr. C. Casuccio (Italy) reviewed twenty-one cases of eosinophilic granuloma of bone and called attention to a peculiar nodular granulomatous structure of histiocytes, as well as the traditional morphological picture. Erythrocytes, sedimentation rate, and cytological findings in the bone marrow were discussed in relationship to definite diagnostic and prognostic significance. Roentgenograms were shown of cases of spontaneous healing and of the successful results of surgical treatment. The author discussed ten cases of vertebra plana and said he found roentgenographic evidence that so-called osteochondritic vertebra plana was an expression of eosinophilic granuloma.

Correction of Flexion of the Knee in Arthritis. Dr. Roger Gariépy (Canada) discussed rheumatoid arthritis, with particular reference to synovectomy, arthroplasty, and joint débridement in correcting flexion contractures of the knee. As a method of correction of flexion deformity of the knee, in which rheumatoid arthritis is quiescent and in which there is good joint motion, the author employed a proximal tibial wedge osteotomy with translocation of the peroneal nerve anteriorly and proximally. This was done in sixteen patients. Although the series is small and the average follow-up is as yet insufficient, it is the author's impression that this method provides an excellent way of improving gait and correcting the flexion deformity without the hazards of vascular or neurological complications. The patient starts motion of the knee approximately twelve or fifteen days after osteotomy and walks in three or four weeks.

Indications for Early Surgery in Cerebral Palsy. Dr. Lenox D. Baker (U.S.A.) reported some observations he made of children with cerebral palsy. He said that normal function of the weight-bearing muscles requires normal alignment of the skeleton; the sooner this is accomplished the easier these children are to train and the better are the results. Adequate recognition of the neuromuscular patterns and their early correction are therefore necessary. If balance and alignment are not established early and maintained, typical deformities, such as pes planus, equinus ankle, adducted flexed hip with coxa valgus, slanting acetabulum, and, possibly, hip dislocation, develop rapidly. If, in the very young child, the deforming forces cannot be overcome with a simple brace (such as Denis Browne spreader, with equinus-preventing outriggers), early carefully selected surgery, such as neurectomy or tenotomy, or both, can control these forces and prevent disabling deformities. These may be carried out as early as necessary. In patients with sufficient involvement to cause deformity, neither braces nor exercise could bring about an appreciable correction. Although surgery could not correct all deformities associated with cerebral palsy, there is still no substitute for properly selected and executed surgery. One must determine, however, the severity of the lesion, the degree of joint motion, and the feasibility of rehabilitation. In a Duke University series of 2,000 patients the most common procedures were: (1) gastrocnemius-aponeurosis lengthening; (2) gracilis tenotomy, often combined with semitendinosus tenotomy; and (3) proximal adductor tenotomy, usually associated with obturator neurectomy. Less frequent, but important, procedures were lengthening or tenotomy of one or more peroneal or tibial tendons. Re-establishing balanced muscle pull between the peroneal and tibial muscles is difficult but should be attempted; if it is not successful, further surgery, such as stabilization and tendon-lengthening, can be performed later. Other useful operations are the Chandler patellar advancement, the Ober myotomy, the Yount fasciectomy, and the Grice extra-articular subtalar stabilization. In carefully selected patients, the proper combination of any or all of these surgical procedures can re-establish normal weight-bearing alignment, bring about an adequate range of motion and stability of joint, and do much to rehabilitate patients with cerebral palsy and make them brace-free. Dr. Baker felt the poor results frequently seen in surgery in this group were often due to poor selection of cases and inadequate surgery; or, "too little and too late".

Osteotomy of the Calcaneus in the Treatment of Grossly Everted Feet, with Special Reference to Cerebral Palsy. Mr. F. C. Dwyer (Great Britain) described an operation for children, particularly those with cerebral palsy, who have severe flat-foot deformity, in which the heel is grossly everted (valgus) and the head of the talus and scaphoid are tilted medially. It is designed for a small percentage of children in whom there is no longitudinal arch and the fore part of the foot is markedly pronated. These patients have a slow and heavy gait, wear their shoes down badly on the inner side, and often have tight Achilles tendons. Most of these children, par-

ticularly those with cerebral palsy, do not respond to simple measures; eventually, stiff and, ultimately, arthritic feet develop. The operation aims at tilting the calcaneus into varus position so that the force of the Achilles tendon is changed from one of eversion to neutral or inversion. The operation first exposes the lateral aspect of the Achilles tendon and curves anteriorly to expose the lateral aspect of the calcaneus by dissecting forward immediately distal to the peroneus longus tendon. The calcaneus is divided below and parallel to the peroneus tendon, transfixed with an awl, tilted into the desired degree of inversion, and maintained with a bone graft taken from the upper part of the inner tibia. In most patients the Achilles tendon is also lengthened by cutting the lateral half of its insertion distally and cutting the medial half proximally at the musculotendon junction (which, in effect, shifts the insertion medially). The new position is maintained in a plaster cast for eight weeks. This operation was used in twelve patients with mobile flat-foot deformity and thirty-four patients with cerebral palsy, mainly spastic. None was made worse, although some of the patients with cerebral palsy were slow in adapting to the new position. Most patients now have improved balance. Mr. Dwyer felt that although there was only a limited place for his operation in mobile flat-foot deformity, there is a greater need for its use in cerebral palsy.

Congenital Talipes Equinovarus, a Concept of Treatment and Surgical Procedure. Dr. R. deMarneffe and Dr. G. Hendrix (Belgium) described their treatment of recalcitrant club-foot deformity. They directed attention toward two locations of the disease, the back part of the foot and the fore part of the foot. They felt that posterior medial release, tendo achillis lengthening, and posteromedial capsulotomy, properly performed, were quite adequate for correction of the back part of the foot. However, anterior correction is more of a problem in the resistant club-foot deformity, where there is anterior supination and adduction. When the first metatarsal ray is lowered (pronation), the cuboid has to rise; conversely, if the cuboid is lowered, the first metatarsal ray is elevated. The authors termed this relationship *the law of interdependence of the longitudinal arches*. Since an irreducible cuboid will prevent correction, they advocate wedge resection of the cuboid. Since 1956, these authors have combined posterior surgical release with osteotomy of the cuboid; they performed twenty-four cuboid osteotomies in children up to nine years of age. They found that it was necessary to remove the blocking mechanism of the external arch to obtain a more normal anatomical correction of the fore part of the foot with less injury and secondary stiffness of the surrounding joints. No alteration of growth of the foot was seen. The authors concluded that: (1) correct reduction of this so-called external arch avoided recurrence; and (2) if proper alignment were obtained prior to nine years of age, osseous procedures later would be unnecessary.

Repairs of Rupture of the Tendo Achillis, with Particular Reference to Old Injuries. Mr. D. L. Savill (Scotland) reported his experience with thirty-five cases of rupture of the Achilles tendon followed for an average of four years. The youngest patient in the group was twenty years of age and the oldest, seventy-eight; the average age was 41.5 years. Of the thirty-five patients, thirty-four were operated on, the remaining patient refused operation. Repair was impossible in one case, the rupture being of ten years' duration. Thus, in thirty-three cases satisfactory surgical repair was carried out. Six of these injuries were at the musculotendinous junction; twenty-nine in the body of the tendon. In fifteen cases simple end-to-end apposition and suture was the procedure, the operation being carried out at an average of 10.5 days from time of injury. In the remaining eighteen cases, the rupture was an average of 5.2 weeks old at the time of repair. In these older cases the tendon was freed by sharp dissection, brought into apposition, and, in addition to end-to-end suture of the tendon, three or four strips of the superficial tendinous raphe were freed from the proximal tendon and dissected down to approximately one inch of the site of rupture. These were then interlaced across the repair site. After repair, the foot was immobilized in full equinus position in a below-the-knee plaster cast for eight weeks. There were six wound infections; one, which was severe, with complete sloughing of the tendon, took six weeks to heal. Nine of the fifteen patients whose rupture was sutured by end-to-end approximation were able to bear full body weight on the toes of the affected foot; seventeen of the eighteen patients on whom fascial strip repair was done were able to rise on the toes of the affected foot.

Muscle Origin Release for Congenital Elevation of the Scapula. Dr. Joseph Woodward (U.S.A.) presented an approach to the correction of congenital elevation of the scapula. This consists of a mid-line release of the origin of the trapezius from the spinous processes of the third cervical to the ninth thoracic vertebra, and, after carefully raising this muscle, a similar release of the origins of the major and minor rhomboids. Care in establishing proper cleavage planes was emphasized. The omovertebral bone is then resected extraperiosteally with due precautions to avoid injury to the spinal accessory nerve. The scapula is drawn downward until the

spine is at the same level as the normal scapula. Because of hypoplasia the lower border of the scapula cannot be brought to the level of the normal scapula without brachial-plexus traction and possible paresis. The origins of the released muscles are resutured lower in the mid-line and the redundant fold in the lower trapezius caused by this new attachment is excised and resutured.

The author presented examples of satisfactory improvement in appearance and function following this procedure.

The Radio-Humeral "Meniscus" and Its Relation to Tennis Elbow. Dr. Henrique de Goes (Brazil) believes that the explanation for tennis elbow is found inside the radiohumeral joint itself, instead of in the periarticular tissues. The symptoms are caused by repeated trauma of a hypertrophic invaginating capsular fold which becomes inflamed and edematous. The author bases his opinion on an anatomical study of twenty-eight elbows of cadavera, along with nine surgical explorations of patients with tennis elbow.

Normally, there is a thin synovial fold attached to the outer and posterior aspects of the radiohumeral capsule which overlies the radial head like a half ring; hypertrophy of this fold was described by some anatomists. Elbow dissections on cadavera revealed two elbows without such a fold, seven with a rudimentary fold, and three with a hypertrophied meniscus-like capsular invagination covering about one-third of the articular surface of the radial head. In two additional cadavera each elbow was different: one had no fold on the right and a hypertrophied fold on the left. Nine consecutive surgical explorations on patients with tennis elbow showed a meniscus-like fold filling the joint laterally and posteriorly. Microscopically, this proved to be a capsular structure covered by synovial lining; it varied in consistency from soft and edematous to tough and fibrous. All patients operated on became symptom-free after excision of this hypertrophied fold and there were no recurrences.

Peripheral Blood Circulation in Patients with Poliomyelitis, Measured by Testing the Vasodilatation Reflex in Relation to the Severity of Motor Paralysis. Dr. Rafael Esteve (Spain) reviewed the vasomotor response in the lower extremities of forty-three patients who had paralysis following poliomyelitis. Reflex vasodilatation was produced by immersing the patient's hand in hot water and measuring the temperature response in the lower extremities. Of forty-three patients, fourteen demonstrated normal responses and eighteen showed slight differences in response in both lower extremities. Ten of the remaining eleven patients had manifest circulatory disturbances; three extremities of the patients in this group showed abnormal vasodilatory reactions in the absence of paralysis and three patients showed no vasodilatory response. The author found no constant relationship between the degree of paralysis and abnormal vasomotor response. He concluded that factors other than motor paralysis produce circulatory and nutritional disturbances in the poliomyelitic patient and that these factors may arise in lesions of the autonomic nervous system.

Experimental Induction of Congenital Defects. Prof. P. K. Duraiswami (India) presented examples of defective growth produced by the injection of various teratogenic agents, such as insulin, isonicotinic acid hydrazide, 3-acetylpyridine, lead nitrate, and cortisone. Injections made at various times in the initial period of incubation of chicken eggs produced specific deformities; injections made simultaneously of different agents into different areas of the yolk produced different deformities. The author attributed these changes to teratogenic specificity which is due to specific biochemical, metabolic, or other changes caused by the respective substances. Since modern embryology conceives of the embryo, including the human embryo, as many groups of cells proliferating and differentiating under the directions of so-called organizers which secrete specific chemical substances which, in turn, are interfered with by various teratogenic agents, the author feels that these animal experiments may lead to a better analysis of the problem of congenital human defects.

Observations of an Extensive Periosteal Change as a Result of Trans-section Paralysis with Myelodysplasia. Dr. Gerhard Exner (Germany) discussed periosteal changes observed in the femora and tibiae of two children with paralysis of the lower extremities secondary to myelocele.

The first patient, a boy, was approximately two and one-half years old at the time of lengthening of both Achilles tendons and closed manipulation of the feet. There was a lumbosacral myelocele with spina bifida; both lower extremities were paralyzed. The boy also had bilateral club-foot deformity. Three weeks after operation exercises were started with the patient in a plaster cast covering the lower extremities and trunk. Ten weeks after operation swelling and increased skin temperature were noted about the knees. Roentgenograms showed periosteal

changes in the supracondylar region of both femora and the right tibia. Fourteen months later there was complete regression except for evidence of myositis ossificans in the adductor muscles of the left hip region.

The second patient, a girl, was twenty-six months old at the time of subcutaneous tenotomy and closed manipulation for bilateral club-foot deformity. Paralysis of both lower extremities was associated with meningomyelocele. During the first five months after operation recovery was complicated by fever caused by urinary-tract infection. During this period periosteal changes were noted in the shafts of both femora and tibiae. Six months after operation roentgenograms demonstrated, in addition to both periosteal ossification in the diaphyses and bone atrophy, a zone in the right femoral neck similar to that observed in Milkman's disease and an infraction of the supracondylar region of the left femur. There was no evidence of scurvy, and a biopsy of the shaft of the left femur revealed normal bone. Thirteen months after operation the periosteal changes had regressed but there was separation of the capital epiphysis of the right femur and the child had coxa vara.

Dr. Exner believes that the periosteal changes were caused by mechanical factors resulting from weight-bearing. Bone atrophy was present in both patients. It was probable that spontaneous fractures occurred in the second patient. The periosteal changes regressed in both patients despite continued weight-bearing.

Orthopaedic and Traumatic Skeletal Lesions in Ancient Egyptians. Dr. Philip Salib (Egypt) reviewed current knowledge of diseases of the skeletal system that occurred among ancient Egyptians. Drawings on the walls of temples and monuments, statuettes, paleopathology, and papyri offer the chief source of information.

The mummy of Pharaoh Siptah (nineteenth dynasty—1215 B.C.) disclosed club-foot deformity. Achondroplasia was demonstrated by statuettes of Chnoum-Hotep and Seneb; skeletons found in the royal necropolis also showed signs of the disease. Observed too were deformities that could have been caused by dyschondroplasia. Skeletal lesions caused by rickets were rare; those caused by syphilis were not encountered. Tuberculosis of the spine seemed to occur most frequently in the lumbar region. Although pyorrhea alveoloris was prevalent, evidence of osteomyelitis was rarely observed. There is evidence that spondylitis deformans and osteo-arthritis must have occurred frequently. Tumors, such as osteoma and osteosarcoma, have been identified.

Traumatic lesions were common. A series of 6,000 skeletons of all ages and historical periods were examined; evidence of fracture appeared in one out of every thirty-two. Fracture of the forearm (31.2 per cent) was most frequent, whereas lesions of the clavicle (13.7 per cent), femur (12.5 per cent), and long bones (10 per cent) were less common. Coxa vara with shortening of the extremity followed fracture of the femoral neck. External splinting seems to have been the chief method of fracture treatment.

The Edwin Smith papyrus (1700 B.C.), to be found in New York, is probably a copy of an older manuscript, written at least 1,000 years earlier. It is the oldest known surgical treatise and is the chief source of information concerning surgical treatment during that period.

The Abnormal Pelvic Development in Mongolism. Dr. W. F. Taillard and Dr. H. J. Kaufmann (Switzerland) agreed with the definition of Lejeune and associates that Mongolism is a chromosomal aberration. They also said that the disease is of special interest to the orthopaedic surgeon because it involves a characteristic and recognizable abnormality of the hip joint, as first pointed out by Caffey and Ross in 1956, when Dr. Taillard and Dr. Kaufmann began their study of sixty cases of Mongolism. The data accumulated represent clinical, roentgenographic, and anatomical investigations of the disease. The authors generally confirmed the finding of a low-index acetabular-roof angle and suggested that this finding is of great significance, especially in infants, where precise confirmation of the diagnosis is important.

Pedicle Bone Graft in Hip Arthrodesis. Dr. Knud Jansen (Denmark) described fourteen arthrodeses of the hip in which the greater trochanter was transferred in pedicle fashion to function as a graft with intact blood supply, as recommended by Haas and by Valls. Dr. Jansen found that this method enhanced the healing of bones; all fourteen patients he operated on showed solid union by three months. Supplementary stabilization was achieved by internal fixation (nail). After the report on the fourteen arthrodeses was completed, the author discussed a recent arthrodesis in which union was not achieved and supplementary iliac pedicle-grafting was required.

AMERICAN ACADEMY FOR CEREBRAL PALSY

The Annual Meeting of the American Academy for Cerebral Palsy was held in Pittsburgh, Pennsylvania, from October 5 to October 7, 1960, under the Presidency of Dr. Raymond R. Rembolt. George W. N. Eggers, M.D., Galveston, Texas, is President for the ensuing year.

The newly elected officers are:

President-Elect:	Jessie Wright, M.D., Pittsburgh, Pennsylvania;
Vice-President:	Russell Meyers, M.D., Iowa City, Iowa;
Secretary:	Joseph D. Russ, M.D., New Orleans, Louisiana;
Treasurer:	Samuel B. Thompson, M.D., Little Rock, Arkansas.

A highlight of the program was a panel on Involuntary Motion, moderated by Alvin J. Ingram, M.D. The discussion covered a half-day session; the panelists included W. M. Phelps, M.D., Chester A. Swinyard, M.D., William Berenberg, M.D., Cyril B. Courville, M.D., Meyer A. Perlstein, M.D., Margaret H. Jones, M.D., Jessie Wright, M.D., Russell Meyers, M.D., and Orlando J. Andy, M.D.

Another innovation this year consisted of small-group round tables on such topics as ocular disabilities, spastic dislocation of the hip, the evaluation of results in cerebral palsy, new concepts in the management of neurological birth defects, aphasia, the management of seizures and their neurophysiological relationship to cerebral palsy, the relation of cerebral anoxia to cerebral palsy, bracing in cerebral palsy, and hearing rehabilitation.

The Instructional Courses given were: Orthopaedic Surgery in Cerebral Palsy—Lower Extremity, Henry H. Banks, M.D.; Recent Advances in the Rehabilitation of Communicative Disorders in Cerebral Palsy, Eugene McDonald, Ed.D.; Techniques of Physical and Occupational Therapy in Cerebral Palsy, Harriet Gillette, M.D.; The Evaluation and Management of a Cerebral Palsied Child under Three Years of Age, Margaret H. Jones, M.D.; The Diagnosis, Classification, and Principles of Treatment of Cerebral Palsy, Meyer A. Perlstein, M.D.; The Neurophysiological Basis of Cerebral Palsy, Chester A. Swinyard, M.D.; The Functional Treatment of Cerebral Palsy, George G. Deaver, M.D.; and Orthopaedic Surgery in Cerebral Palsy—Upper Extremity, J. L. Goldner, M.D.

A résumé of the scientific program follows:

Flexor Carpi Ulnaris Transplant and Its Uses in Cerebral Palsy. Dr. William T. Green and Dr. Henry H. Banks[1] reviewed the indications for transplantation of the tendon of the flexor carpi ulnaris to the tendon of the extensor carpi radialis in cerebral palsy. The techniques and results were illustrated. The procedure has the virtue of relieving a deforming factor and of aiding both dorsiflexion of the wrist and supination of the forearm.

General Considerations of Muscular Hypotonia. Dr. Hans Zellweger[2] defined muscular tone as the resistance to passive movement provided by a muscle at absolute rest. The neurophysiological bases of muscle tone and its aberrations are poorly understood. Yet, muscle tone is commonly evaluated in clinical neurology. Variations of normal muscle tone are found frequently, particularly in children. In this paper, muscular hypotonia was described and its different causes were enumerated and briefly discussed.

Muscular hypotonia can be caused by disturbances of the electrolyte metabolism (hypopotassemia, hyperpotassemia, hypercalcemia, and probably hypophosphatemia), by a number of endocrine disorders (hypo-adrenalism, hypercorticism, and von Recklinghausen's disease), by lesions located within the peripheral reflex arch, and by supraspinal lesions.

A slide was shown which illustrated the different nerve circuits involved in supraspinal regulations and the different levels at which hypotonia can originate. The clinician, however, encounters many cases of supraspinal hypotonia in which he is not able to localize the site of origin of the hypotonia accurately. A number of conditions in which hypotonia originated in lesions in the supraspinal circuits was enumerated.

Cerebral Angiography by the Brachial Route in Infants and Children as an Aid in the Diagnosis of Cerebral Palsy. Dr. Frederick Murtagh[3] reported that the underlying pathology of cerebral palsy is very often vascular in origin. The mechanism is generally considered to be a traumatic injury to the cerebral vascular tree during delivery or shortly thereafter. In an unknown number of instances, cerebral vascular accidents occur spontaneously within a few days

1. 300 Longwood Avenue, Boston 15, Massachusetts.
2. State University of Iowa, Iowa City, Iowa.
3. 506 Germantown Avenue, Philadelphia 44, Pennsylvania.

of birth or at any time thereafter; these may be due to the rupture of aneurysms or of vascular channels in cerebral angiomata.

Pathology of the cerebral vascular system can be diagnosed accurately only by cerebral angiography. This is best accomplished in infants and children by injecting the contrast material into the right brachial artery and making roentgenograms in rapid sequence.

At Temple University Medical Center and at St. Christopher's Hospital for Children, two distinct techniques have been employed:

1. For children past infancy, the brachial artery is exposed in the right arm, a large-calibre cannula is placed in the vessel, thirty cubic centimeters of 50 per cent hypaque is rapidly injected into this artery, and films are made on the Chamberlain biplane stereoscopic angiographic device which makes stereoscopic films in both the anteroposterior and lateral planes at 0.7 second intervals as the contrast medium passes through the arterial, capillary, and venous systems.

2. In infants the cardiac rate is much more rapid, and the biplane stereoscopic angiographic device is not satisfactory in this age group. The same injection technique is used with cinefluorography. The dye is injected into the right brachial artery, but the films are made in a single plane, using a high-speed movie film and image intensifier.

Selective Surgical Procedures in the Cerebral-Palsied Hand. Dr. Alfred B. Swanson [4] reported that reconstructive surgery in the upper extremity may fortify the usual rehabilitative measures of splinting and muscle re-education in a small group of patients with cerebral palsy. Long-standing muscle imbalance which only surgery can improve may prevent the attainment of the full functional potential of a cerebral-palsied hand. Emphasis was placed on the need for thorough preoperative evaluation by muscle-testing, bracing, splinting, procaine nerve blocks, and sensory examination. A group of cases were presented in which several selective procedures, including arthrodesis, tenodesis, and tendon transfers, had been performed.

The Collaborative Project on Cerebral Palsy, Mental Retardation, and Other Neurological and Sensory Disorders of Infancy and Childhood. Dr. Richard L. Masland [5] said that the Collaborative Project on Cerebral Palsy, Mental Retardation, and Other Neurological and Sensory Disorders of Infancy and Childhood is the first large-scale effort to collect information on all factors that might conceivably have a bearing on these disorders. It is the first research program ever undertaken to collect and analyze this information before, rather than after, such disorders develop. It will involve, over a period of five years, a total of 50,000 women in all parts of the country. The record keeping will begin in early pregnancy and continue into the early years of life of the children. The project brings into close collaboration, with each of the women selected for study, obstetricians, pediatricians, and specialists in at least a dozen other medical and scientific disciplines. A single study design has been developed so that all data conceivably having a bearing on any disorders that might occur among the children will be collected and recorded in a uniform manner. A total of fifteen hospitals and universities across the country are collaborating on the study with the National Institute of Neurological Diseases and Blindness of the Public Health Service's National Institutes of Health.

Electrical Stimulation of Paired Muscles as a Means of Determining Sidedness. Dr. David Rutherford and Mr. Richard M. Cole [6] conducted an exploratory investigation to determine whether differences in neuromuscular excitability of muscles on the right and left sides of the body might serve as an indicator of sidedness. Strength-duration curves were obtained on homologous muscles in the following categories: flexor-extensor, proximal-distal, dorsal-ventral, pronator-supinator, and rostral-caudal. The subjects were college-age males in good health and without known neuromuscular abnormalities. The testing procedure followed closely that generally used in routine electrodiagnosis. Complete strength-duration curves were obtained on each subject on two different occasions to permit a check on the reliability of the measurements.

To date, the data suggest that neuromuscular excitability of the muscles on one side of the body differs systematically from that on the opposite side of the body for all the muscles tested, and that the side of the body exhibiting lower thresholds for electrical stimulation tends to coincide with the side of the dominant hand in these adults. Additional investigation is under way to determine whether the same phenomenon can be observed in young children prior to the age at which handedness becomes apparent.

4. 1810 East Wealthy Street, Grand Rapids, Michigan.
5. National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Maryland.
6. Northwestern University School of Speech, Evanston, Illinois.

The Recommendations and Follow-up Program Evolving from the 1960 White House Conference on Children and Youth. Dr. Alfred R. Shands, Jr. [7], was a member of the President's National Committee for the Golden Anniversary White House Conference on Children and Youth, Chairman of Forum XVI dealing with the youth with physical handicaps. He is now actively engaged in planning for the White House Conference follow-up. His presentation dealt chiefly with the recommendations arising within the forum on the youth with physical handicaps, presenting plans for the follow-up program and outlining the physician's role in this program.

Treatment of Dystonia Musculorum Deformans Progressiva. Dr. Winthrop M. Phelps [8] presented a delineation of dystonia musculorum deformans progressiva, its differential diagnosis, a review of the literature on the disease, and a discussion of treatment.

The author's personal experience was based on a long-term follow-up of fourteen cases seen between 1936 and 1953. The treatment and results in these cases were described. No case was considered which had not been followed for at least five years; some had been followed up to twenty years.

Ataxia-Telangiectasia: A Syndrome in the Progressive Ataxias of Childhood. Dr. Elena Boder and Dr. Robert P. Sedgwick [9] reported additional observations on a familial syndrome for which the term *ataxia-telangiectasia* was proposed by the authors in a preliminary report published in 1957. The preliminary paper and the second, more complete report, published in *Pediatrics* in 1958, were based on eight cases, six of them familial, and the first known necropsy.

Ataxia-telangiectasia is a familial progressive cerebellar ataxia beginning in infancy which is characterized by progressive telangiectasia noted first in the exposed bulbar conjunctivae, where it simulates conjunctivitis, and later in the skin. The patients with this syndrome are prone to sinus and pulmonary infections, including bronchiectasis, and have peculiar eye movements simulating ophthalmoplegia.

Other features of ataxia-telangiectasia are: characteristic facies, variable choreo-athetoid movements and postures, cerebellar speech, drooling, hair and skin changes, retardation of growth, equable disposition, and absence of mental deficiency.

The essential components of the syndrome are ataxia and telangiectasia, the most striking identifying feature being the characteristic telangiectases of the bulbar conjunctivae. Ataxia-telangiectasia can thus be diagnosed at a glance.

The available pneumo-encephalograms give evidence of cerebellar atrophy. The most striking finding at necropsy was an apparently primary, chronic, diffuse, cortical cerebellar degeneration affecting mainly the Purkinje cells without significant changes in the spinal cord.

With the exception of a clinical report on a single non-familial case published in French in 1941 by Louis-Bar, no reports on this syndrome were found in the literature prior to the publication of the authors' preliminary paper in 1957. Since that time, however, ten other papers, based on thirteen more cases and three necropsies, have appeared in the literature, making a total of twenty-two cases with four necropsies published to date.

Awareness of ataxia-telangiectasia and its early diagnosis will eliminate painful and often dangerous diagnostic procedures such as air study, angiography, and posterior-fossa exploration for neoplasm. The correct diagnosis will permit early recognition of bronchiectasis, so that appropriate antibiotic therapy can be promptly instituted.

The Importance of, and Methods of Assessing, the Ability of the Child with Cerebral Palsy to Produce Intraoral Pressure during Speech. Mr. James C. Hardy [10] pointed out that there are data available which indicate that certain minimum amounts of oral air pressure are needed to produce the sounds of certain consonants. Much of these data have come from work with children who have cleft palates. There is good reason to believe that some children who have cerebral palsy may be unable to produce the necessary pressure within the mouth for at least two reasons. First, they may be unable to generate such pressure owing to paralysis of the breathing mechanism; second, paralysis of the palate may impair velopharyngeal closure during speech. As a result, air leaks from the oral cavity and prevents any build-up of pressure in the mouth.

Diagnostic methods now being used at the Hospital School for Severely Handicapped Children, State University of Iowa, to assess athetoid and spastic children's ability to develop intra-oral pressure were presented. A technique was suggested for the determination of the site of the diffi-

7. The Nemours Foundation, Wilmington, Delaware.
8. 3038 St. Paul Street, Baltimore 18, Maryland.
9. Beverly Hills, California.
10. Hospital School for Severely Handicapped Children, State University of Iowa, Iowa City, Iowa.

culty (the breathing mechanism or the velopharyngeal port). This technique utilizes an oral manometer and respirometer. Lateral roentgenograms of the head and cinefluorographic and spirometric techniques were explained. These are used to obtain some indication of a patient's ability to achieve velopharyngeal closure and thus develop oral pressure. The pressure developed during the production of prolonged speech sound can be compared with that developed during connected speech. Data obtained by such techniques from patients with cerebral palsy were presented, and the implications of these data for the prognosis and clinical management of speech problems resulting from oral-pressure deficiencies were suggested.

Results of Orthopaedic Surgical Procedures in Cerebral Palsy. Dr. William Cooper and Dr. William D. Arnold [11] reported the results and the relative effectiveness of various orthopaedic operative procedures performed over a ten-year period in a group of approximately 300 patients. These patients represent a closely followed and carefully studied group under the same medical supervision for the whole ten-year period. The minimum follow-up after surgery was one year with an average time of approximately four to six years. The authors stated that this represents one of the largest groups of carefully followed and supervised patients with cerebral palsy who have undergone various orthopaedic procedures.

Use of Sensory Modalities in the Training of the Hemiplegic Infantile Cerebral Palsy Patient. Dr. Margaret H. Jones [12] pointed out that two facts suggested a trial of this method might be worth while: first, reports of a direct correlation between the amount of function of an extremity and the degree of sensory deficit; second, failure of the usual passive and active assisted exercises and active muscle training to achieve functional results. In an adult hemiplegic, whose dysfunction was due mainly to sensory loss, Forester reported success in sensory training.

Dr. Jones had studied the sensory loss in patients of various ages with infantile hemiplegia to obtain a base line for a program of training. In this presentation she reported the results of a study of about ten children with sensory deficits who received combined visual, auditory, and tactile stimulation training. This training was of two types: one utilizing graded performance of the affected hand with reward; the other incorporating multiple sensory stimuli in a story form. The sensory deficits of the children were repeatedly tested and correlated with their development of function. Observations of carry-over into nursery activities were included.

Preliminary findings indicated some success with this approach.

Vestibular Findings in Various Types of Cerebral Palsy. Dr. Nicholas Torok and Dr. Meyer A. Perlstein [13] reported that very little has been written about the possible changes in the vestibular apparatus in children with cerebral palsy. By the use of specialized techniques, the vestibular function of approximately 350 children with cerebral palsy was tested. A great number of patients had vestibular involvement, but at the same time a great many children with cerebral palsy had normal vestibular reactions, in spite of balance difficulties. There are two types of cerebral palsy, however, in which vestibular changes are very common and generally characteristic of the condition—namely, spastic hemiplegia and kernicterus. In the hemiplegic group, there is generally hyperirritability of the vestibule on the involved side of the brain. In kernicterus, there is generally bilateral hypoactivity of the vestibules. Hypoactivity of the vestibules is more commonly seen in children who have auditory involvement or severe auditory aphasia.

Critical Appraisal of Present Rehabilitative Techniques in Cerebral Palsy. Dr. Lawrence T. Taft, Dr. Arthur S. Abramson, Dr. Edward Delagi, and Dr. O. L. Wilkie [14] emphasized that many of the present techniques used in the rehabilitation of children with cerebral palsy are based on empiricism and not on basic neurophysiological concepts.

An attempt was made to analyze critically the therapeutic management of cerebral palsy, with special reference to the recent advances in neurophysiology and kinesiology. From this analysis, conclusions were drawn as to the validity of present techniques and suggestions were made for future research.

Experiences with Relaxant Drugs in Cerebral Palsy: 1949–1960. Dr. Eric Denhoff and Dr. Raymond H. Holden [15] stated that various relaxing drugs believed to be of value in cerebral palsy were studied over a twelve-year period by a standardized technique in which both drug and placebo were used alternately on children with cerebral palsy.

11. 535 East 70th Street, New York 21, N.Y.
12. 742 Via de la Paz, Pacific Palisades, California.
13. 4743 N. Drake Avenue, Chicago 25, Illinois.
14. Eastchester Road and Morris Park Avenue, New York 61, N.Y.
15. 293 Governor Street, Providence, Rhode Island.

In these studies emphasis was placed upon both the neuromotor and over-all behavioral effects. Subjects were primarily preschool children with cerebral palsy. The majority were spastic and had borderline-normal or normal intelligence.

In addition to routine physical, neurological, and psychological examinations and assessments on the basis of personal-social-behavior rating scales, experimental testing situations were developed to evaluate changes in body anxiety.

Over a twelve-year period, ten drugs with matched placebos were utilized. The percentage of improvement due to these drugs varied from 20 to 53 per cent. These results indicated that the effects of the placebos were as great as or sometimes greater than the effects of the drugs. These results emphasize that drug administration in cerebral palsy has great psychological effect on the patient.

Any conclusions as to the efficacy of drug therapy must be made with caution.

A Correlation of the Etiological Factors, the Lesion-Complexes and the Clinical Syndromes in Cerebral Palsy. Dr. Cyril B. Courville [16] said it had been proposed that the nature of the underlying cerebral alterations can be predicted on the basis of the resultant clinical syndromes. This proposition has been extended to include the concept that the nature of the brain damage can be determined on the basis of the known etiological factors. The value of such information, if it were valid, is quite apparent. The facts, however, prove that these concepts are oversimplifications of the basic nature of the lesions causing cerebral palsy. This seems to be demonstrated by the writer's survey of 160 verified cases of cerebral palsy in which enough of the history was known to attempt a correlation of the etiological, clinical, and pathological data. It was found that in malformations, their disclosure at autopsy often came as a surprise, since the history was always obscure. In the group of cerebral lesions characterized by progressive deteriorations during the first year of life any one of a fairly large series of lesions might be found. Even in the children with fairly clear-cut histories of dystocia, the nature of the cortical-subcortical defect at best could only be roughly approximated. The cerebral lesion could be fairly accurately estimated only in the children in whom the etiological factors other than birth injury were fully appreciated. This study was concerned with a classification of cases on this basis.

16. Cajal Laboratory of Neuropathology, Los Angeles County Hospital, Los Angeles, California.

WESTERN ORTHOPEDIC ASSOCIATION

As Prepared by the Editorial Committee: Robert Mazet, Jr., M.D., *Chairman*, John R. Schwartzmann, M.D., Howard A. Mendelsohn, M.D., Harry C. Hughes, M.D., and R. G. Lambert, M.D.

The Twenty-fourth Annual Meeting of the Western Orthopedic Association was held in Coronado, California, October 23 through October 27, 1960, under the Presidency of Dr. Fraser L. MacPherson. In addition to a program of excellent papers from the various chapters of the Western Orthopedic Association, a seminar on Orthopaedic Aspects of Space Flight was presented. R. C. Armstrong, M.D., *Head*, Aerospace and Radiation Medicine Group, Convair, San Diego, California, gave a paper entitled "Human Stresses in Space"; D. W. Conover, Ph.D., *Head*, Human Factors and Engineering Group, Convair, San Diego, California, "Human Engineering—Problems in Space Vehicle Design"; and D. A. Liebel, *Group Supervisor* in the Mechanism Design Group, Convair, San Diego, California, read his paper, "Physical Stresses in High Speed Escape Systems". There was also a seminar on Problems in Amputee Research. Verne T. Inman, M.D., Ph.D., Professor and Chairman of the Department of Orthopaedic Surgery, and *Director*, Biomechanics Laboratory, University of California, read a paper on "Amputee Research—An Inter-Disciplinary Approach"; S. William Levy, M.D., Assistant Clinical Professor of Dermatology and Assistant Research Dermatologist, University of California, San Francisco, "Skin Disorders of the Lower-Extremity Amputee"; Henry J. Ralston, Ph.D., Instructor in Physiology and Research Physiologist, University of California, San Francisco, "Measurement of Energy Expenditure in Normal and Disabled Human Subjects"; and Charles W. Radcliffe, M.E., Associate Professor of Mechanical Engineering and Engineering Coordinator, University of California, San Francisco, "Engineering Contributions to Research in Biomechanics".

The Vernon P. Thompson Resident-Training Program awards were made under a new plan this year. Of the numerous papers submitted, the Resident-Training Committee selected four for presentation at the meeting. The quality of these four papers was superlative. They were so nearly alike in value it was impossible to award prizes on the usual basis. Each of the authors, therefore, was given a certificate expressing appreciation, and a monetary award to defray his expenses of the meeting. The following were so honored: Wayne L. Norton, Captain, MC, USA, Fitzsimons Army Hospital, Denver, Colorado, for "Fractures and Dislocations of the Cervical Spine"; James R. Doyle, M.D., Children's Hospital of the East Bay, Oakland, California, for "Stimulation of Bone Growth by Short Wave Diathermy"; James M. Morris, M.D., University of California Medical Center, San Francisco, California, for "The Role of the Trunk in Spine Stability"; and Gerald S. Laros, M.D., Shriners' Hospitals for Crippled Children, Honolulu, Hawaii, for "The Effect of Constant Measured Compression upon the Healing of Fractures in Long Bones".

Dr. Marvin T. Knight was installed as *President* for the coming year.

Officers elected for 1961 were:

President-Elect: Donald E. King, M.D., San Francisco, California;
Vice-President: Dorsey K. Barnes, M.D., Dallas, Texas;
Secretary: B. Clyde Halley, Jr., M.D., Dallas, Texas;
Treasurer-Historian: Carl E. Anderson, M.D., Santa Rosa, California.

The next Annual Meeting will be held at the Statler-Hilton Hotel, Dallas, Texas, October 17 through October 21, 1961. The 1962 Meeting will be held at the Fairmont Hotel, San Francisco, California, October 28 through November 1. The 1963 Meeting will be held in Seattle, Washington.

Summaries of the papers presented follow:

Small but Symptomatic Fractures of the Acetabular Rim Unaccompanied by Dislocation of the Hip. Dr. J. S. Blaisdell[1] reported on two small fractures of the acetabular rim caused by relatively trivial trauma in young adults. Both patients had been treated for hip sprain, bursitis, or mild arthritis before the proper diagnosis was made. Exploration of both these hips disclosed fragments from the acetabular rim lying within the joint. Removal of these resulted in cure.

Dr. A. H. Rodi[2] suggested, in discussion, the possibility that these small fragments may have been detached at the time of unrecognized, spontaneously reduced, dislocation of the hip. He showed roentgenograms of three patients in whom small acetabular fragments within the joint

1. 1801 B, No. Broadway, Santa Ana, California.
2. 2010 Wilshire Boulevard, Los Angeles 57, California.

had caused disability until removed. He stated that planograms are sometimes helpful in making the diagnosis and that the hip should not be dislocated at the time of exploration.

Athletic Avulsion Fractures in the Pelvic Region. Dr. E. Paul Woodward [3] said that avulsion fractures of the traction epiphyses in the pelvic region are probably more common than one would anticipate from a review of the literature. The author collected twenty-three cases of avulsions following sudden strong muscle contracture. Of these avulsions, thirteen were from the anterosuperior iliac spine; one from the anterior-inferior iliac spine; two from the lesser trochanter of the femur; six from the ischial tuberosity; and one, separation of the epiphysis of the ischial tuberosity. Illustrative case histories and roentgenograms were presented. Conservative therapy had given good results in twenty-two of the twenty-three cases.

Dr. N. Meadoff [4], in discussion, added three cases to those reported by Dr. Woodward. He agreed that conservative therapy is the method of choice.

Extruded Lumbar Intervertebral Discs in Pseudospondylolisthesis. Dr. Gwilym B. Lewis [5] and Dr. Arthur Holstein [6] presented two cases of pseudospondylolisthesis in which routine roentgenograms revealed a forward displacement of the fourth lumbar on the fifth lumbar vertebra, without a neural-arch defect. The patients had acute sciatic symptoms. In both cases, myelograms and subsequent surgery proved the cause of the sciatica to be due to disc extrusion at the fifth lumbar-first sacral level, rather than at the level of the pseudospondylolisthesis. The authors pointed out that this finding was of interest in view of the theory that pseudospondylolisthesis is caused by an anomaly of the pedicle-facet angle and subsequent disc degeneration at the spondylolisthesis level.

Dr. Norman Harris [7] brought out, in discussion, the fact that disc degeneration may occur at other levels than that at which displacement occurs. He also reiterated the acknowledged fact that myelograms are not entirely reliable.

Traumatic Spondylolisthesis. Dr. R. G. Lambert [8] and Dr. E. L. Billings [9] reported that traumatic spondylolisthesis is a rare condition; they were able to find few proved cases in the literature. They presented two instances in which spondylolisthesis followed fracture of the body of the vertebra and of the neural arch. One patient fell ten feet from a ladder, landing on his back. The other was in a motorcycle accident. The authors presumed these displacements were the direct result of the trauma. They cited some previous papers which point out the possibility that pre-existing weakness of the pars interarticularis, perhaps on a familial basis, with superimposed stress, may be a contributing or causative factor in the development of the usual spondylolisthesis.

Dr. Homer C. Pheasant [10], the discussor, pointed out that a sufficient force supplied over a long enough time would cause fracture of any bone, whether it be a great force applied instantaneously or a small force over a long period. He thought that there is no accurate way of determining whether or not spondylolisthesis is caused by trauma.

Comparison of Results in the Surgical Treatment of Disc Lesions with or without Fusion. A Combined Orthopaedic and Neurological Surgical Section Study. Dr. John D. Leidholt [11], Dr. M. E. Gibbens [12], and Dr. K. Welch [13] presented follow-ups on ninety-nine patients who were operated on for intervertebral-disc lesion. In twenty-eight no disc lesion was found. Thirty-five were treated with disc excision only, and thirty-six were treated with excision and attempted fusion. Of these, 80 per cent were followed for more than three years after operation. Evaluation was by hospital records, questionnaire, and re-examination. The results were less than satisfactory: 75 per cent of patients with disc lesions treated without fusion had satisfactory results or better, as compared with 58 per cent in the patients with fusion. Only 20 per cent of the patients with fusion had good to excellent results. The fusions in these cases were of two types, Hibbs or Bosworth, using iliac bone or bank bone, or both. There was roentgenographic evidence of pseudarthrosis of the fusion area in 27 per cent of the patients with a single level fused, and in 79

3. 2330 First Avenue, San Diego 1, California.
4. 2634 G Street, Bakersfield, California.
5. 3011 Telegraph Avenue, Berkeley 5, California.
6. 3011 Telegraph Avenue, Berkeley 5, California.
7. 375 Park Avenue, Coos Bay, Oregon.
8. 2554 4th Avenue, San Diego, California.
9. 2554 4th Avenue, San Diego, California.
10. 1401 South Hope Street, Los Angeles 15, California.
11. 1855 Gaylord Street, Denver 6, Colorado.
12. Veterans Administration Hospital, Denver 20, Colorado.
13. Veterans Administration Hospital, Denver 20, Colorado.

per cent of those in whom more than one level was fused. In compensation patients only 13 per cent had good to excellent results. A comparison of previous similar studies was included in the report. The authors agree with The American Orthopaedic Association's 1952 committee report that fusion should not be done with initial disc excision and that compensation cases be excluded from this type of clinical study.

DR. RICHARD Q. LEWIS [14], in discussion, said that, in his experience, results in patients who did not have fusion were much better than those in the patients who had fusion.

Anterior Intervertebral Disc Excision and Interbody Fusion of the Cervical Spine. DR. FRANK L. RANEY, JR., [15] and DR. JOHN E. ADAMS [16] reported twenty patients on whom they had performed anterior interbody fusion of the cervical spine. The details of their operative technique were given. It varied a little from the techniques previously reported—they removed the entire disc. They excised any spurs, both anteriorly and posteriorly. They also removed all of the cartilaginous plates of the adjacent vertebrae, except for the posterior two millimeters, to prevent the bone graft from penetrating into the neural canal. They inserted a wedge-shaped graft with the apex posteriorly in order to minimize the possibility of posterior extrusion. No postoperative immobilization was used. Better results were obtained in those patients who obtained preoperative relief by traction than in those who did not. Of nineteen patients who had preoperative neck pain, seventeen had obtained relief after operation; in fifteen, this neck pain persisted throughout the period of follow-up. In eighteen patients who had both cervical and radicular pain preoperatively there was postoperative relief in sixteen and in fourteen pain persisted for the duration of the follow-up. There was one instance of temporary hoarseness; one instance of hemorrhage and laryngeal edema; and one instance of dysphagia, all resulting in intense coughing and anterior extrusion of the grafts. One patient had foot-drop after operation. There were three instances of pseudarthrosis. In nine patients fusion was at two levels; in five, at three levels; and in three, at four levels. There was no long-term follow-up of these patients.

The discussor, DR. GERALD G. GILL [17], advocated discography at time of surgery to increase accuracy of diagnosis.

Osteoporosis and Its Relationship to Back Pain. DR. DAVID W. ANDERSON [18] supported, on the basis of clinical observations, the hypothesis that osteoporosis is a physiological condition in which bone production is less than bone resorption, and that one of the main etiological factors is a relative preponderance of antianabolic hormone. He cited the work of Paulson and Nielsen, of Seattle, whose estrogen-excretion studies on elderly female patients tend to substantiate the lack of estrogen excretion in patients with compression fractures. He advocated sex hormone treatment and rejected the use of high calcium intake.

In discussion, DR. MARSHALL R. URIST [19] cited the results of recent studies with radioisotopes that revealed high rates of bone resorption and normal rates of bone formation in patients with osteoporosis. He also pointed out that sex hormones have a placebo effect, that high calcium intake can promote as much calcium retention as estrogen, and that, therefore, calcium and sex hormones may be prescribed together to advantage.

A Non-Surgical Method of Treating Sprengel's Deformity. DR. HERBERT E. HIPPS [20] presented a non-surgical method of treating Sprengel's deformity which seeks to correct the cosmetic appearance of the patient by teaching the patient the habit of holding the normal shoulder even with the abnormally high shoulder. This preliminary report gave the results in seven patients. The patient is taught to hold the normal low shoulder up even with the other shoulder in two ways: (1) by teaching and training methods and (2) by use of a conditioned response method using a conditioned response brace.

Slides were presented showing the results in three of the cases.

A review of psychology textbooks concerned with habits, habit formation, and duration of motor-habits had convinced the author that this motor-habit once acquired will, in all probability, be permanent.

The Vascular Pattern of Bone of the Extremities. DR. JOHN C. NORK [21], DR. J. E.

14. 3030 34th Street, Lubbock, Texas.
15. 3580 California Street, San Francisco, California.
16. 3580 California Street, San Francisco, California.
17. 516 Sutter Street, San Francisco 2, California.
18. 1118 Ninth Avenue, Seattle, Washington.
19. 1019 Gayley Avenue, Los Angeles 24, California.
20. 1612 Columbus Avenue, Waco, Texas.
21. Duke University Medical Center, Durham, North Carolina.

MARKEE [22], and DR. W. B. JONES [23] made a study of the vascular pattern of bones of thirteen freshly amputated extremities removed for reasons other than vascular insufficiency and processed within thirty minutes of amputation. The vascular bed was injected with methyl methacrylate. Some of the specimens were then studied after complete digestion of bone matrix and minerals had been done by chemical means, leaving only the plastic vascular pattern. In others the bone matrix was not dissolved, and sections were made of the entire bone. These studies demonstrated the following: the arterial supply to bone is derived from four sources; nutrient, metaphyseal, epiphyseal, and periosteal. Venous drainage is by two means; large vessels at the end of long bones, and numerous small subcortical sinusoids draining into periosteal veins. There is a separate arterial and venous system. No paired vessels were noted. There is communication between the Haversian and Volkmann systems. The vascularity of spongy bone is mostly venous.

In discussion, DR. J. ROBERT CLOSE [24] said that this contribution to our knowledge of the vascular pattern in the long bones is a welcome addition to our fund of knowledge.

Iliac Osteotomy. DR. WILLIAM SNELL [25] presented eight instances of iliac osteotomy performed for the treatment of congenital exstrophy of the urinary bladder, accompanied by a bone defect in the region of the symphysis pubis. Subsequent urological repair of the bladder was done in each instance. The operation was done through two parallel incisions just lateral to the sacro-iliac joints. The gluteus maximus was reflected subperiosteally and the intrapelvic surfaces freed of soft tissue. The osteotomy was then made just lateral to the sacro-iliac joints. The pelvis was compressed, bringing the rami of the pubis into approximation. The bladder repair is done a few days later. All the osteotomies healed promptly. In several instances there was a slight loss of correction, with widening of the space between the two pubic bones. The external rotation deformity of the hips which exists in these patients is corrected by the osteotomy with improvement of gait.

The paper was discussed by DR. J. R. SCHWARTZMANN [26].

Grease Gun Injuries of the Hand. DR. HERBERT H. STARK [27], DR. JAMES N. WILSON [28], and DR. JOSEPH H. BOYES [29] reported four cases of an uncommon hand injury caused by the injection of a fine stream of oil from a grease gun. The oil, which is delivered under high pressure, penetrates the skin, distends the soft tissues, and frequently lodges in tendon sheaths. Unless the pressure is relieved, the tissue involved becomes ischemic, pain becomes intense, and tissues die and slough. There is subsequent fibrosis and scarring due to chemical irritation, and infection sometimes occurs. The acute case should be treated as a surgical emergency and as much grease as possible should be removed. Reconstructive procedures are often needed subsequently to restore maximum function. Only eighteen cases have been previously reported. Since this method of lubrication is used by the jet plane and missile industries, it can be anticipated that such injuries will be seen more often.

Two-Stage Flexor-Tendon Reconstruction in the Hand: The Use of a Polyethylene Catheter. CAPT. H. A. MARKOWITZ [30] reviewed eight instances in which a polyethylene catheter was implanted in a finger in an effort to induce the formation of a tunnel through which a tendon graft could function. In each instance a tendon graft had previously failed, but there was so much damage to the area that tendon-grafting alone was not feasible. Following implantation of the polyethylene catheter a partially smooth, partially hyalinized fibrous-tissue tunnel was created.

The discussor, DR. JAMES N. WILSON [31], pointed out that the adventitious bursa formed about the polyethylene tubing does not create a good blood supply for a tendon graft threaded through it.

Knee Disarticulation—A Technique and Prosthesis. DR. ROBERT MAZET, JR.,[32] and MR. CHARLES A. HENNESSEY (C. P. and O.) [33] reported that knee disarticulation presents several advantages over above-the-knee amputation when below-the-knee amputation will not suffice. The procedure is done more quickly, is less shocking, and cuts through no bone or muscle. Full

22. Duke University Medical Center, Durham, North Carolina.
23. Duke University Medical Center, Durham, North Carolina.
24. 2929 Summit Street, Oakland, California.
25. University of Oregon Medical School, Portland, Oregon.
26. 2415 East Adams, Tucson, Arizona.
27. 1401 South Hope Street, Los Angeles 15, California.
28. 1401 South Hope Street, Los Angeles 15, California.
29. 1401 South Hope Street, Los Angeles 15, California.
30. United States Naval Hospital, San Diego, California.
31. 1401 South Hope Street, Los Angeles 15, California.
32. 2400 S. Flower Street, Los Angeles 7, California.
33. 402 W. Washington Boulevard, Los Angeles, California.

control of the stump is retained. Weight is borne on the femoral condyles, which naturally perform this function. The patient has better balance, and walks with a more natural gait. The stump stands up well. The unsightliness of the bulbous stump end, ungainliness of the prosthesis, and frequent breakdown of standard external knee joints have militated against wide acceptance of this operation, despite its definite advantages.

An operative technique which minimizes the bulbous stump end and a cosmetically acceptable prosthesis with a new type of external knee joint were described. A patient who had been walking on the device for a year and a half and working every day was presented.

Resident Training Program

Fractures and Dislocations of the Cervical Spine. Capt. Wayne L. Norton [34] analyzed in detail the skeletal and neurological changes observed in eighty-eight patients with fractures and dislocations of the cervical spine seen at Fitzsimons General Hospital between 1950 and 1959. The methods of diagnosis and the treatment were also described. The eighty-eight patients were military personnel and dependents—seventy-three men and fifteen women. Their average age was twenty-four years. Most of the injuries resulted from automobile accidents (sixty-two patients) or from falls on the head or neck (thirteen patients); diving into shallow water was the cause of injury in eight. Seventy-two patients had one or more demonstrable fractures; the remaining sixteen had dislocations or subluxations without demonstrable fracture. Thirty-two patients had significant dislocations or subluxations combined with their fractures.

In all, there were 102 individual fractures. Of these, 56 per cent involved the centra of the third cervical to first thoracic vertebra inclusive, 28 per cent involved these same vertebrae elsewhere than in the centra, and 16 per cent involved the first and second cervical vertebrae. Neurological injuries occurred in forty-seven of the eighty-eight patients. Initial complete quadriplegia occurred in twenty-one patients; only three of these had a good recovery. Initial partial cord damage occurred in fourteen, of whom twelve had good recoveries. Transient nerve-root symptoms occurred in six patients; all recovered.

It was emphasized that the first consideration must be to protect the spinal cord of the patient suspected of having a neck injury and that the routine use of emergency splinting or bracing and attendance by a trained physician is mandatory if neurological damage is to be kept to a minimum. Because of the dangers of flexing or extending the neck, the neutral position is considered to be the safest position for emergency transportation. Good-quality roentgenograms are the key to accurate diagnosis. If initial roentgenograms disclose an apparent unstable fracture or dislocation, further roentgenograms should be deferred, and all other therapy, except lifesaving resuscitation should be delayed; the patient should immediately be placed in skull caliper traction. Because Crutchfield tongs have occasionally pulled out of the calvarium and because the inner table of the skull had been penetrated by the old-design Crutchfield tongs in two patients, Vinke tongs are now preferred. Traction was employed routinely on Foster or Stryker frames, regardless of the neurological status of the patients.

After the fracture or dislocation had been reduced and immobilized in skull traction, definitive treatment was instituted. In this series, sixty-three patients were treated conservatively. Of these, four were quadriplegic and died soon after injury; seven were quadriplegic and were treated on the neurosurgical service or transferred to other hospitals, and, hence, fusion was not considered. Fifty-two patients had minor stable fractures or injuries to the cervical spine for which conservative management had been instituted elsewhere, the patient coming to Fitzsimons General Hospital during convalescence. Conservative treatment included six weeks or more of skeletal traction, immobilization in a Minerva plaster jacket for six to twelve weeks in selected cases, and support in a light cervical brace for two to six additional weeks. At the conclusion of treatment, flexion-extension roentgenograms were made to check the stability of the injured region. Of the sixty-three patients conservatively treated, forty-eight were returned to military duty within an average of four and a half months.

Twenty-five patients with unstable fractures, dislocations, and subluxations at various levels were treated by early internal fixation with wire and posterior spine fusion. Operation was performed when the patient's general condition was optimum. The procedure was carried out with the patient on a Foster frame with continuous skull traction. Endotracheal anesthesia through a nasal tube was used. The operative technique was similar to that described by Rogers.

One of the twenty-five patients so treated required a second operation after the wire broke and the fusion failed. Seventeen patients were returned to military duty, and three civilian dependents were discharged home well; three quadriplegic patients were transferred to a Veterans Administration hospital, and two quadriplegic patients were retired from military service. The average

34. Fitzsimons General Hospital, Denver 30, Colorado.

time from injury to return to duty was six and a half months; the average delay from injury to fusion was two months. The average time from fusion to return to duty was four and a half months; in recent injuries it was three and a half months.

The author concluded that unstable injuries of the cervical spine can be managed successfully by prolonged skeletal traction, but the instability will recur in 10 to 12 per cent of cases. The treatment of choice in unstable fractures without severe neurological injury is internal fixation and posterior spine fusion.

Stimulation of Bone Growth by Short-Wave Diathermy. Dr. James R. Doyle [35] reviewed the experimental and clinical endeavors to increase leg length as presented in the literature and reported a method for the stimulation of bone growth by short-wave diathermy in experimental animals. Discrepancy in leg length is a frequent and often severe disability; the problem is commonly encountered after poliomyelitis, femoral fracture, and local infectious processes. Although Phemister's epiphyseodesis and Blount's stapling technique are practical methods for correction of leg-length discrepancy, the observation that increased growth and elevated temperature of a limb have occurred in such conditions as arteriovenous fistula, hemangioma, and osteomyelitis near an epiphysis suggested that it might be profitable to study the effects of local heat on bone growth in the rat. Twenty female rats of the Long-Evans strain were used, with a similar group as controls. Insulated copper plates, which allowed for the administration of diathermy to one of the hind limbs of four to six animals simultaneously, were made for a short-wave medical diathermy apparatus (27.120 kilocycles). Treatment was given under intraperitoneal nembutal anesthesia and was directed mainly to the epiphyses of the right knee in each animal. The amount of diathermy was regulated to increase the temperature of the limb to 40 degrees centigrade, 3 degrees centigrade above the rat's normal body temperature. The temperature of the extremity during treatment was determined by an externally placed thermistor. All animals were treated for approximately one-half to one hour each day, or on alternating days, from the twenty-first to the seventieth day of life. The average total duration of diathermy administration was twenty-five hours. The body temperature of the rats, as determined by an externally placed thermistor, did not change during treatment. The animals were kept for an additional ten days after the conclusion of treatment. At eighty days they were sacrificed, and the lengths of the tibiae and femora of the treated and untreated limbs of the experimental animals and of both hind limbs of the control animals were measured with a caliper. Microscopic sections of the femoral and tibial epiphyses were also prepared. Six experimental and two control animals expired before the end of the experiment. The increase in the combined length of the treated tibiae and femora over the untreated limbs varied from 0.4 millimeter to 2.8 millimeters, the average being 1.4 millimeters. Measurements of the tibiae and femora in the control group revealed no discrepancy in limb length. No histological changes were noted in the treated and untreated bone and cartilage. It was concluded that diathermy produces deep tissue heating, increased blood flow, and localized or diffuse hyperemia and thereby acts as a stimulus to the growing epiphysis.

Role of the Trunk in Stability of the Spine. Dr. James M. Morris [36] noted that the calculated loads on the spine during lifting are considerably in excess of the forces that the spine can withstand as determined experimentally on cadaver material. He reported experiments designed to test the hypothesis that the action of the trunk muscles converts the thoracic and abdominal cavities into nearly rigid-walled cylinders filled, respectively, with air and with liquid and semisolid material and that these cylinders are capable of resisting a part of the force generated during lifting, thereby relieving the load on the spine itself.

Ten healthy males were used as subjects and their trunks were loaded under various conditions. During loading the intrathoracic and intra-abdominal pressures were recorded by means of two open-tip polyethylene catheters—one introduced into the esophagus, the other into the stomach. Simultaneously, the electrical activity of the intercostal muscles, the abdominal oblique muscles, the rectus abdominis, and the deep muscles of the back were recorded by electromyography. Loading of the trunk was accomplished in two ways: (1) dynamically by having the subjects lift from the floor weights ranging from 0 to 200 pounds, first with the knees flexed and the spine straight and then with the knees straight and the spine flexed, and (2) by having the subject pull against a strain ring exerting a force up to 200 pounds, first with the trunk vertical and then with the trunk flexed to 30, 60, and 90 degrees. Motion pictures were made to permit correlation of the subjects' position with the pressure and the electromyographic activity. Static tests were also carried out on a few subjects while wearing a corset with an air cushion over the abdomen inflated to the limit of comfort.

35. Children's Hospital of the East Bay, Oakland, California.
36. Department of Orthopaedic Surgery, School of Medicine, University of California, San Francisco, California.

In the dynamic tests there was little increase in pressure or muscular activity during forward bending, but the pressure rose rapidly as lifting began, reaching a maximum just as the weight was lifted from the floor. The rectus abdominis muscle was generally less active than the oblique muscles. Intra-abdominal pressure was more elevated during lifting with the knees flexed and the spine straight than in the other position. Intrathoracic pressure was not affected by the position. More pressure was developed in the subjects of large stature.

During the static tests the intra-abdominal and intrathoracic pressures were nearly identical with the trunk upright. As the trunk was flexed on the thighs, the intra-abdominal pressure increased while the intrathoracic pressure remained unchanged. The oblique muscles were active in all positions, their activity being proportioned to the intra-abdominal pressure. The rectus abdominis was only slightly active in the vertical position but its activity increased progressively with flexion of the trunk. The activity of the intercostals remained approximately the same or decreased slightly with trunk flexion. The activity of the deep muscles of the back increased with the load and was somewhat less in the upright than in the flexed position.

In the tests with the corset, the intrathoracic pressure was elevated slightly or not at all. The intra-abdominal pressure was increased by an amount comparable to that occurring when the corset was not worn. While the corset was worn, the activity of the abdominal muscles, both the recti and the obliques, was considerably and consistently decreased. If the corset extended over the thorax the activity of the intercostals was also decreased.

Using the data obtained from these experiments the forces on the spine were calculated. It was concluded that during lifting the actual force on the spine was 35 to 45 per cent less than the theoretical force because of the support provided by the trunk muscles by means of the increased intra-abdominal and intrathoracic pressure.

The Effect of Constant, Measured Compression of Various Magnitudes upon the Healing of Fractures in Cortical Long Bones. Dr. Gerald S. Laros [37] said that the study was an attempt to evaluate the effect of constant, measured compression of various magnitudes on the healing of fractures in the cortex of long bones.

Transverse mid-shaft fractures of the tibia were produced in twenty-five rabbits by means of a Gigli saw after inserting, perpendicular to the long axis of the bone, two Kirschner wires above, and two below, the site of fracture. The rabbits were divided into five groups, with five rabbits in each group. Each group of five fractures received different treatments as follows: (1) rigid fixation with the Kirschner wires clamped to steel medial and lateral side bars, (2) physiological compression with the wires held by medial and lateral sliding couplings that permitted compression of the fracture site by muscle contraction but prevented rotation and angulation, (3) minimum compression (500 grams of total force, or 27 pounds per square inch on the fracture ends) produced by means of sliding spring clamps attached to the wires on the medial and lateral sides of the limb, (4) intermediate compression (1,000 grams of total load, or 55 pounds per square inch) produced by similar but stronger spring clamps, and (5) maximum compression (2,000 grams of total force, or 110 pounds per square inch) applied by still-stronger spring clamps. The progress of healing was followed by periodic roentgenograms. The animals in each group were sacrificed at four days and one, two, three, and six weeks after fracture, and histological sections were prepared from each fracture site.

The roentenographic studies showed no differences in the five groups with respect to the appearance of anchoring, bridging, and uniting callus. However, of the five fractures carried through six weeks of healing, only those receiving physiological and minimum compression showed obliteration of the fracture line.

The histological studies showed that union seemed to progress to maturity more rapidly in the groups with physiological and minimum compression than in the other three. In these two groups the callus was less profuse, contained less cartilage, and showed a higher degree of organization. No clear-cut explanation for the differences in healing was apparent. The positions of the fragments fixed by physiological and minimum compression seemed to improve during the early phases of healing, indicating that these types of fixation permitted some readjustment of position as the result of muscle action. This phenomenon was suggested as a possible cause of the better healing in these two groups. In the fractures with intermediate and maximum compression, necrosis and disintegration of the bone ends did not appear to be the major deleterious effect. Instead, disruption of the living bone along Haversian canals was observed. This suggested that the excessive compression acted as a stimulus for the reorganization of the bone, with cellular resorption of bone centrally and excessive callus formation peripherally. As a possible explanation for the slower healing with intermediate and maximum compression, it was proposed that the healing process might, under

37. Shriners' Hospital for Crippled Children, Honolulu, Hawaii.

these conditions, be dissipated by the production of an increased volume of callus at the expense of union between the bone ends. It was also suggested that these findings might indicate that mechanical factors of fixation affect the tissue in the organizing callus rather than the bone ends. The author concluded that these experiments did not show whether compression, as distinct from improved contact and immobilization, was of benefit.

Long-Term Follow-up of Treatment of Comminuted Fractures of the Distal End of the Radius by Transfixation with Kirschner Wires and Cast. Dr. Max Scheck [38] reported thirty-seven comminuted fractures of the distal end of the radius in which the reduction had been maintained with skeletal fixation by means of Kirschner wires through the second, third, and fourth metacarpals and through the proximal end of the ulna. A long arm cast incorporated the wires. Three of the cases were the Smith type of reverse Colles fracture. Nineteen of the twenty-four patients with adequate follow-up had satisfactory results and none had gross deformity. Five had some minor restriction of activity.

In discussion, Dr. Harold E. Crowe [39], pointed out that the soft-tissue damage resulting in edema and loss of function was often more important than the fracture of the radius, and that restoration of function was an integral part of the treatment of fractures.

Late Treatment of Perilunar Dislocations. Dr. Charles R. Ashworth [40] reviewed six cases of perilunar dislocation seen two or more weeks after injury. In three there was an associated fracture of the carpal scaphoid. Open reduction and internal fixation with Kirschner wires gave satisfactory results in four instances; in one, wrist fusion was necessary. A seventh case of dislocation which was reduced operatively recurred because no internal fixation had been used.

Treatment of Congenital Dysplasia of the Hip and Its Sequelae. Dr. Sherman S. Coleman [41] reported that the clinical manifestations of congenital dysplasia of the hip vary in different age groups and in different patients of similar ages. In general, the clinical findings, whether in a newborn or an older child, reflect the basic pathological condition present. This, in turn, determines the treatment to be instituted. In treatment, the application of three basic principles is essential: (1) to place, or hold, the femoral head in the acetabulum; (2) to secure a stable hip; and (3) to restore, insofar as possible, the normal anatomy of the hip joint.

Except in teratologic infants, the dysplastic hip is rarely dislocated at birth, and secondary changes are usually not present in the newborn. In these cases, since the hip is quite stable in abduction, splinting in the frog-leg position is all that is usually necessary. Untreated, the dysplasia may gradually lead to subluxation or dislocation, with its resultant secondary changes.

If dislocated, the ease or difficulty of reduction determines the need for closed or open reduction, and for rigid immobilization; the degree of anteversion governs the position of immobilization and the indication for subsequent derotation osteotomy; and the configuration and depth of the acetabulum, among other factors, decide the need for acetabuloplasty.

A plea was made for the prompt recognition of the early signs of dysplasia in order that simple non-operative methods might be instituted. The development of later changes inevitably compromises the end result, often requiring surgery for correction of sequelae.

The discussor, Dr. E. G. Chuinard [42], stressed the following: that the reduction be obtained by the least traumatic method possible and that it be maintained for a sufficient period of time. He pointed out that underdevelopment of the acetabulum may necessitate operation later. Subtrochanteric osteotomy has been helpful in creating anteversion and producing coxa vara, which aids in maintaining reduction.

Posterior Shoulder Dislocations. Dr. Robert L. Samilson [43] and Dr. Earl Miller [44] reviewed the literature on posterior dislocations of the shoulder and added nine of their own cases to the 183 cases already reported. The mechanics of recurrent posterior dislocations were demonstrated by means of cinearthrographic studies of a patient who could voluntarily dislocate his shoulder posteriorly. The etiology, clinical signs, roentgenographic findings, treatment, and prognosis were discussed in detail.

An important observation regarding the mechanics of recurrent posterior dislocation of the shoulder in two habitual dislocations demonstrated by cinearthrography was that a so-called

38. 500 Spruce Street, San Francisco 18, California.
39. 635 South Westlake Avenue, Los Angeles 57, California.
40. 2400 S. Flower Street, Los Angeles 7, California.
41. 2033 South State Street, Salt Lake City, Utah.
42. 1922 N. W. Johnson, Portland 9, Oregon.
43. 3580 California Street, San Francisco, California.
44. 1242 West Lincoln Avenue, Anaheim, California.

setting of the scapula always took place before dislocation. The scapula rotates about an axis in the scapular spine and the glenoid tips forward, the acromion moves downward and forward, and the inferior angles moves medially. This leaves only the inferior portion of the posterior rim of the glenoid as a buttress against dislocation. When the humerus rotates internally to clear the greater tuberosity from beneath the acromion, dislocation occurs.

Arthrodesis of the Knee by Double Plating. Dr. Donald B. Lucas [45] and Dr. William R. Murray [46] described a technique for knee fusion utilizing two eight-inch stainless-steel plates applied at right angles to each other to immobilize the femur and tibia after erasure of the joint surfaces. The resulting fixation eliminates the necessity for external immobilization in most instances. The patella is excised and portions used to fill any irregularities along the joint margins. Weight-bearing is delayed until there is roentgenographic evidence of fusion. The authors obtained fusion in sixteen knees with a variety of pathological conditions, including four Charcot joints and two knees in which previous fusions had failed. In one patient the initial attempt with the two large plates failed, and the operation had to be repeated.

In discussion, Dr. Irvin E. Hendryson [47] said that double-plate fixation is a sound mechanical means of immobilization, and undoubtedly contributes to the success of this fusion technique. A method which is consistently successful in fusing Charcot knees is sound.

The Etiology and Treatment of Recurrent Dislocation of the Patella. Dr. Leonard Barnard [48] stated that recurrent dislocations of the patella are due to muscle imbalance, a dysfunction of the vastus medialis for one of several reasons. There may be an anomalous insertion, developmental weakness, or paralysis. The malfunction permits unbalanced pull on the lateral side of the patella by the iliotibial band and the vastus lateralis. This imbalance causes dislocation and results in deformity of the patella, lateral femoral condyle, and so forth. An effective repair must: correct the overaction of the iliotibial band and vastus lateralis; reef the medial capsule and advance the vastus medialis downward on the patella; and move the insertion of the patellar tendon in the tibia medially, if abnormalities of the femur and patella have developed. The author reported no cases.

Dr. F. E. West [49], the discussor, believes that not all cases are due to vastus-medialis malfunction. The lateral dislocation may have several causes. These may be traumatic, underdevelopment of the femoral condyle, or malformation of the patella.

Benign Chondroblastoma: Report of an Unusual Case. Dr. Walter C. Graham [50], Dr. Dean A. Smith [51], and Dr. Fred R. Smith [52] presented a case of a benign chondroblastoma occurring near the epiphysis of the upper part of the humerus in a thirty-nine-year-old pituitary dwarf. Roentgenographic examination of all the extremities showed retarded skeletal maturation with persistent epiphyseal lines in the distal portion of the tibia, fibula, radius, ulna, and some of the phalanges of the hands. Laboratory studies confirmed the impression of anterior pituitary insufficiency. The tumor was treated surgically and has not recurred.

Benign chondroblastoma most commonly occurs in young individuals whose epiphyses still possess growth potential. It has been reported in adults and when it does occur, its location is near the epiphyseal end of a long bone.

The occurrence of benign chondroblastoma in adults was discussed. A review of the literature failed to reveal any report of a similar case of chondroblastoma occurring in an adult with demonstrable retarded skeletal maturation.

The discussor, Dr. Carl Anderson [53], emphasized the fact that this is an uncommon tumor in a rare endocrine disorder. He doubted if there was any connection between the two.

The Results of Repair of the Sciatic Nerve. Dr. D. Kay Clawson [54] discussed repair of 145 lesions of the sciatic nerve. (Previously published, J. Bone and Joint Surg., **42-B**: 213–225, May 1960.)

45. University of California Medical Center, San Francisco 22, California.
46. University of California Medical Center, San Francisco 22, California.
47. 1750 Race Street, Denver 6, Colorado.
48. 2939 Summit Street, Oakland 9, California.
49. 2850 6th Avenue, San Diego 3, California.
50. 1421 State Street, Santa Barbara, California.
51. 1421 State Street, Santa Barbara, California.
52. 1421 State Street, Santa Barbara, California.
53. 1150 Montgomery Drive, Santa Rosa, California.
54. BB-429 University Hospital, University of Washington Medical School, Seattle 5, Washington.

Congenital Dislocation of the Knee. Dr. John J. Niebauer [55] and Dr. Don King [56] presented a motion picture demonstrating congenital dislocation of the knee in an infant, a two-year-old boy, a twelve-year-old girl, and a sixty-seven-year-old woman. The salient points of physical examination and pathology were demonstrated. Three different operative procedures used to correct different manifestations of this deformity were shown.

The Tight Heel Cord. Dr. Louis J. Levy [57], Dr. Cuvier P. Lipscomb [58], Dr. Henry C. McDonald [59], and Dr. Charles P. Davis [60] pointed out that heel-cord tightness does exist as a definite clinical entity and is a frequent precipitating factor in the production of foot symptoms, disabilities, and deformities. This paper discussed the pathogenesis and formation of foot disabilities associated with the tight heel cord, and stressed the proper use of physical therapy in conjunction with other methods of treatment.

The authors believe that the equinus deformity produced by the tight heel cord causes strain on the longitudinal arch, stretching of the transverse metatarsal ligaments, and splaying of the fore part of the foot. The usual shoe corrections were believed to be ineffectual until the heel cord had been stretched.

Dr. Stanley S. Tanz [61], the discussor, did not believe that heel-cord tightness is a primary cause of foot disabilities as described by the authors.

Paget's Disease of the Facial Bones. Dr. Bernard J. Drury [62] presented an unusual instance of Paget's disease of the skull in which there was marked hyperostosis of the facial bones, proved by microscopic studies. Differential diagnosis and pathology were discussed and a method of treatment was outlined. Reports of similar cases were reviewed.

55. 516 Sutter Street, San Francisco 2, California.
56. Stanford Hospital, San Francisco, California.
57. 918 8th Avenue, Fort Worth, Texas.
58. 918 8th Avenue, Fort Worth, Texas.
59. 918 8th Avenue, Fort Worth, Texas.
60. 918 8th Avenue, Fort Worth, Texas.
61. 1548 N. Norton Street, Tucson, Arizona.
62. 317 W. Pueblo Street, Santa Barbara, California.

DAVID STEPHEN GRICE

1914–1960

Orthopaedic surgery lost one of its outstanding surgeons in the tragic death of Dr. David Stephen Grice in an airplane crash on October 4, 1960.

Dr. Grice, the son of John and Elizabeth Fry Grice, was born in Chicago on July 9, 1914. There he spent his childhood, attending the Nicholas Senn High School. In his senior year, he was the Commanding Officer of the High School Reserve Corps. He received his A.B. degree from the University of Rochester in 1935, where he was an outstanding athlete in football, track, and baseball. He was captain of the football team in his junior year. That was his last year of eligibility, since he went on to medical school at the University of Rochester, receiving his M.D. in 1938.

His decision to go into medicine came early during his preparatory school years, but football was a major factor in his choosing to become an orthopaedic surgeon. He had a football injury to his knee which required an operative procedure. Certain complications following this greatly prolonged his convalescence and, in fact, caused him to have intermittent difficulty with the knee from that time on. This experience stimulated his interest.

After graduating in medicine from the University of Rochester, he served an internship followed by an assistant residency in surgery at the Strong Memorial Hospital in Rochester. He had his resident training in orthopaedic surgery in Boston at the Children's Hospital and the Massachusetts General Hospital, finishing his last year of training in 1943–1944 as chief resident in orthopaedic surgery at the Children's Hospital. In 1944 he became a member of the Staff at the Children's Hospital and an assistant in orthopaedic surgery at Harvard Medical School. This began an association with Harvard Medical School, the Children's Hospital, and the Peter Bent Brigham Hospital which lasted until 1958. During this period in Boston he was an immediate associate of Dr. William T. Green, with his offices at the Children's Hospital Medical Center, and was intimately concerned with the teaching program at Harvard Medical School, the resident training program at the Children's Hospital, and the general activities of the Department.

In 1958 he was appointed Chairman of the Department of Orthopaedic Surgery and Professor of Orthopaedic Surgery at the University of Pennsylvania. At the time of his resignation to accept this position he was Assistant Professor at Harvard Medical School, Orthopaedic Surgeon at the

Children's Hospital Medical Center, Associate in Surgery at Peter Bent Brigham Hospital, Associate Director of the Massachusetts Infantile Paralysis Clinics, Orthopaedic Consultant to the Mary MacArthur Respirator Unit, a Consultant to the Massachusetts Crippled Children's Services, and a Lecturer in Anatomy at Simmons College.

Dr. Grice had the opportunity to serve for a period of just over two years at the University of Pennsylvania. During this period, however, he had already demonstrated those qualities of leadership which were his. One of his confreres, a chairman of a department with whom he worked very closely, after recounting his many accomplishments during his short tenure, made the following comment: "He had won the confidence and affection of the entire staff of the Hospital and the high regard of the preclinical faculty. We will all miss his leadership and sound judgment, not only in the Department of Orthopaedics but in the Medical School as a whole."

Dr. Grice was blessed with many attributes—brilliant of mind, original in his ideas, discerning, and critical. He carried in all his activities an enthusiasm which was boundless and exceeded only by his determination and persistence in striving to get the job done in the best possible way. There was no compromise with expediency. He was a stimulating teacher who loved to teach and gave of himself to the full. He was exciting in his graphic demonstrations and descriptions. He strove for the clear thinking mind in his students, and the easy, sloppy way was intolerable to him. Many a resident burned under his searing criticism of the moment only to appreciate it the next day and to cherish and respect his teaching forever after with increasing enthusiasm as time went on. He was an inspiring lecturer, much appreciated by medical students. With all this, he had a sense of humor which was appreciated by all those who were associated with him.

He was an excellent clinician and a keen investigator. His contributions to orthopaedics were many. His writings were not extensive in number but they were important in their significance. He wrote on many phases of poliomyelitis, its therapy and surgical treatment. His particular interest over most of his medical career was in pediatric orthopaedics. The procedure of subtalar extra-articular arthrodesis, which he first described, was well conceived. It has become a procedure which has demonstrated its worth and should remain as one of our classic procedures in surgery. His judgments were good, and his counsel was much sought and appreciated. He had the happy faculty of going directly to the crux of the problem, analyzing the factors involved, and quickly coming to a decision.

He was an individual of strong convictions and deep emotions. He created those same feelings in others. He was selfless in his desire to accomplish what he felt should be done. Time and effort had no limitation. He had a great feeling of responsibility for orthopaedic surgery and for his duty as an orthopaedic surgeon. His patients meant much to him, and they, in turn, had great affection for him. He was a disciplinarian with his patients, with himself, and with those who trained under him, yet this was not discipline for discipline's sake but discipline to accomplish his objective. His mind was orderly and incisive and he tried to instill this attribute in others. He was long associated with the Massachusetts Infantile Paralysis Clinics at the Children's Hospital in Boston, of which he was Associate Director. It was particularly gratifying to see the morale and enthusiasm which he instilled in the patients of this Clinic. How much he was appreciated by his patients and by his associates in Boston was demonstrated by the fact that as a spontaneous expression of their feelings a memorial fund was established for him at the Children's Hospital Medical Center where he had been for so many years. The respect which he had already engendered amongst his confreres at the University of Pennsylvania is shown by the fact that an official memorial fund was established at the Orthopaedic Department there, where he had been for such a short time.

Dr. Grice married Mary Burns of Rochester, New York, on March 30, 1940, while he was an assistant resident in surgery at Strong Memorial Hospital. This was a happy marriage. Mary was a great complement to her husband in all his activities, and she and three daughters—Patty, nineteen, now in her sophomore year at Vassar; Martha, fifteen, and Constance, twelve, in school in Philadelphia—survive him. In all the family activities Dave participated with the same enthusiasm that was characteristic of his medical career. One of the family's choicest times and spots was a cottage on a Massachusetts lake where they spent their summers. As might be expected, it was within a relatively short driving distance of the Hospital and his work.

Dr. Grice was a member of The American Academy of Orthopaedic Surgeons, The American Orthopaedic Association, the Forum Club, and the American Board of Orthopaedic Surgery to which he was recently elected; at the time of his death he was a trustee of the University of Rochester.

W. T. G.

News Notes

Part I Examination of **The American Board of Orthopaedic Surgery** will be held on June 19 and 20, 1961, in Philadelphia, Pennsylvania; Nashville, Tennessee; and Palo Alto, California. The deadline for filing applications was January 1, 1961.

Part II Examinations, oral and written, will be given in Chicago, Illinois, on January 24, 25, and 26, 1962. The deadline for filing applications is July 1, 1961.

Inquiries should be sent to Dr. Sam W. Banks, *Secretary-Treasurer*, **The American Board of Orthopaedic Surgery, 29 East Madison Street, Chicago 3, Illinois.**

Kappa Delta Award—1961

The Committee on Scientific Investigation of The American Academy of Orthopaedic Surgeons announces that all manuscripts which are to be entered for the Kappa Delta Award, which is presented annually for the outstanding scientific contribution in the field of orthopaedic surgery and which carries an honorarium of $1,000, should be forwarded to the Chairman of the Committee, Dr. Charles H. Herndon, University Hospitals, 2065 Adelbert Road, Cleveland 6, Ohio, by June 15, 1961. The winner of the award will be asked to present the paper at the Annual Meeting of The American Academy of Orthopaedic Surgeons in January 1962. Therefore, it is suggested that the manuscripts be submitted as early as possible so that the utmost care may be given in evaluating each individual contribution.

Dr. Frank E. Stinchfield, Director of the New York Orthopaedic Hospital of the Columbia-Presbyterian Medical Center, will be the Samuel Higby Camp Visiting Professor of Orthopaedic Surgery at the University of California School of Medicine, San Francisco, from March 20 to March 31, 1961.

The Eighth Annual Meeting of the **Mid-Central States Orthopaedic Society** will be held in Springfield, Missouri, May 4 through 6, 1961.

The **Fifth Post-Graduate Course on Fractures and Other Trauma** sponsored by the Chicago Committee on Trauma of the American College of Surgeons will be held April 19, 20, 21, and 22, 1961, at the John B. Murphy Memorial Auditorium, 50 East Erie Street, Chicago, Illinois. Inquiries should be addressed to Dr. John J. Fahey, Chairman of the Committee on Post-Graduate Course on Fractures and Other Trauma, 1791 W. Howard Street, Chicago 26, Illinois.

The **Yugoslav Association of Orthopaedic and Traumatological Surgeons** has recently been formed in Belgrade. The following officers were elected:

President: Prof. Dr. Dim. Jovtchitch, Belgrade;
Vice-Presidents: Prof. Dr. F. Grospitch, Zagreb;
Prof. Dr. B. Brecelj, Ljubljana;
General Secretary: Prof. Dr. S. W. Stoianovitch, Belgrade;
Treasurer: Doc. Dr. C. Rakitch, Belgrade.

The **First Yugoslav Orthopaedic Congress** will be held in Zagreb in October 1962. The general subjects to be discussed are: Conservative and Surgical Treatment of Congenital Dislocation of the Hip (Lecturer: Dr. F. Grospitch) and Traffic Accidents (Lecturer: Dr. S. W. Stoianovitch). Inquiries should be directed to Prof. Dr. S. W. Stoianovitch, Director of the Orthopaedic Clinic, 26 Visegradska, Belgrade, Yugoslavia.

The **American and Canadian Exchange Fellows** who will tour Great Britain this Spring are:

E. Burke Evans, Galveston, Texas;
J. T. H. Johnson, Baltimore, Maryland;
W. R. MacAusland, Jr., Boston, Massachusetts;
William Snell, Portland, Oregon;
John Hazlett, Kingston, Ontario, Canada.

The Forty-fifth Congress of the **Italian Orthopaedic and Traumatological Association** was held in Florence, Italy, from October 26 through 29, 1960, under the Presidency of Prof. O. Scaglietti, who was re-elected *President* for the next two years.

The main subject discussed was the modern treatment of bone and joint tuberculosis. Papers given were: "Conservative Treatment of Bone and Joint Tuberculosis", Dr. Colombani and Dr. Allaria, Cortina d'Ampezzo; "Surgical Treatment of Bone and Joint Tuberculosis, Except the Spine", Dr. Marconi, Dr. Miravella, and Dr. Bombelli, Venice; "Operative Treatment of Tuberculous Spondylitis", Dr. Calandriello, Florence; "Treatment of Abscesses and Fistulae", Dr. Paltrinieri and Dr. Cesari, Pisa; and "Social Aspects of Bone and Joint Tuberculosis", Dr. Gaeta and Dr. Batini, Rome.

The **Michigan Orthopedic Society** was organized at Boyne Mountain Lodge, Michigan, on September 16 and 17, 1960. Thirty-four orthopaedic surgeons from the upper and lower peninsulas, representing the entire state, met and adopted a constitution and by-laws. The following officers were elected: *President*, Dr. Donald Charles Durman, Saginaw; *President-Elect*, Dr. Victor S. Mateskon, Petoskey; and *Secretary-Treasurer*, Dr. Hira E. Branch, Flint.

All orthopaedic surgeons in Michigan have been invited to join the society; applications may be obtained by writing to Dr. Hira E. Branch, 821 Mott Foundation Building, Flint 2, Michigan.

"Surgery for Surgeons", a Medical Continuation Course, will be presented at the **Center for Continuation Study,** University of Minnesota, May 11 through 13, 1961. For information concerning the course, write to W. Albert Sullivan, Jr., M.D., Director, Department of Continuation Medical Education, 1342 Mayo Memorial, University of Minnesota, Minneapolis 14, Minnesota.

The Fifth Annual Meeting of the **Pennsylvania Orthopedic Society** was held in Atlantic City, New Jersey, on Friday, October 7, 1960, under the Presidency of Edgar L. Ralston, M.D., Philadelphia, Pennsylvania. Papers read were: "The Treatment of Injuries of the Flexor Canal", Dr. James N. Hunter, Philadelphia, Pennsylvania; "Infraction of the Femoral Head Secondary to Prolonged Ingestion of Cortisone", Dr. Dan R. Baker, Sayre, Pennsylvania; "Proposed Changes in Blue Shield According to Relative Value Scale", Dr. William F. Donaldson, Pittsburgh, Pennsylvania; "Report of the Committee on Scientific Investigation", Dr. John J. Gartland, Philadelphia, Pennsylvania; "Presidential Address", Dr. Edgar L. Ralston, Philadelphia, Pennsylvania; "Surgery of the Hand", Dr. John L. Sbarbaro, Jr., Philadelphia, Pennsylvania; "Surgery of the Knee Joint in Chronic Arthritis", Dr. Theodore A. Potter, Boston, Massachusetts; and "Surgery of the Hip", Dr. D. Keith McElroy, New York, N. Y.

Applications for charter membership in the **American Society of Diagnostic Radiology** are now being received. Membership is open to cardiologists, chest physicians, gastro-enterologists, rheumatologists, orthopaedists, pediatricians, otolaryngologists, internists, and general practitioners who do, or may desire to do, some types of diagnostic roentgenography in their offices.

For further information write: Louis Shattuck Baer, M.D., F.A.C.P., 411 Primrose Road, Burlingame, California.

CORRECTION

An error occurred in the December 1960 issue of The Journal in the article Roentgen Aspects of Injuries to the Pisiform Bone and Pisotriquetral Joint by Anthony Vasilas, R. Vincent Grieco, and Noel F. Bartone. The first full paragraph on page 1328 should read:

From this study it would appear that subluxation of the pisotriquetral joint is of **no** clinical significance when associated with fractures of the distal part of the radius.

Book Reviews

THE STRUCTURE AND FUNCTION OF MUSCLE. Vol. I, Structure. Edited by G. H. Bourne. New York, Academic Press, 1960. $14.00.

This, the first of three volumes on muscle, is concerned with structure, and consists of twelve chapters written by fifteen contributors. The topics covered range from movement and posture to ultrastructure, and include microanatomy, development, histochemistry, tissue culture, and nerve supply.

Volume II considers the Biochemistry and Physiology of Muscle and Volume III, Pharmacology and Disease. The three volumes provide comprehensive coverage of most aspects of current knowledge of muscle tissue. The bringing together of different contributors, each a recognized expert, makes the editor's job a difficult one, particularly if he is seeking style and balance. A book of this type is also difficult to review: each chapter is worthy of a review. Nevertheless, certain comments are in order.

All of the chapters are good, some of them especially so. They are well written and well documented. Perhaps it is unfair to single out certain chapters, but Boyd's chapter on development and Walls' on microanatomy are fine examples of the caliber of this volume. Would that some of our student textbooks were written as clearly and concisely as, for example, the part of Walls' chapter dealing with the conducting system of the heart.

I found relatively few omissions in this volume. I would have hoped for an account of the development of cardiac and smooth muscle, as well as of striated muscle. I would also liked to have seen a discussion of the nerve supply of muscle in relation to muscle pain.

I believe that Bourne and his contributors have succeeded admirably in producing a balanced, well written treatise that brings together many important aspects of muscle structure. This volume and the succeeding two constitute important and valuable sources of information.

Ernest Gardner, M.D.

SURGERY OF REPAIR AS APPLIED TO HAND INJURIES. B. K. Rank, C.M.G., M.D. (Melbourne), F.R.C.S. (Eng.), F.R.A.C.S., and A. R. Wakefield, M.D. (Melbourne), F.R.C.S. (Eng.), F.R.A.C.S. Foreword by Sir Gordon Gordon-Taylor. Ed. 2. Baltimore, The Williams and Wilkins Company, 1960. $9.00.

In the current era of the emphasis on secondary reconstruction in hand injuries, it is encouraging to review a book in which the authors direct attention to the imperative need for optimum primary treatment. In many medical centers the care of acute hand injury is relegated to the poorly trained surgeon and the result is frequently disastrous for the patient. The plastic-surgery orientation of the authors calls attention to the necessity for applying the principles of meticulous tissue handling if good results are to be realized.

Rank and Wakefield state that the scope of the book is "limited to hand injuries rather than injuries which affect the hand". In this connection the authors have purposefully chosen not to proceed in detail on the more complex aspects of reconstructive hand surgery, particularly in regard to high, peripheral-nerve lesions. Most noteworthy is their definition of hand wounds as "tidy" or "untidy". This classification carries with it implications as to method of treatment and prognosis and is based on the magnitude of tissue reaction to injury. The fact that primary treatment in untidy wounds should be limited to skeletal realignment and skin closure is extremely well brought out.

The authors' stand on elective surgical approaches in the finger, the role of the paratenon, primary nerve repair, and the use of an Esmarch tourniquet will not meet with universal acceptance. Their experience, however, cannot be challenged.

This book is highly recommended to all physicians dealing with hand injuries and is particularly valuable for the industrial or accident-ward surgeon.

James N. Wilson, M.D.

FRACTURES, DISLOCATIONS, AND SPRAINS. Philip Wiles, M.S. (Lond.), F.R.C.S. (Eng.), F.A.C.S. Boston, Little, Brown and Company, 1960. $7.50.

This book, as stated in the author's preface, consists of a series of roentgenographic reproductions and line drawings prepared from hand-printed display cards prepared and mounted for teaching in the orthopaedic and fracture departments of the Middlesex Hospital, England. The illustrations are excellently compared, with each region covered on a single page. The various types of fractures are well illustrated. The explanatory text is adequate. The illustrations cover diagnoses most adequately. The treatment is discussed in a short, concise manner, as are complications.

Treatment illustrations are sparse. The handling of plaster and the application of casts are not illustrated. The bound volume measures ten inches by twelve and three-quarter inches and lends itself well for the arrangement of the illustrations, but eliminates the book from being carried in the pocket of a ward coat or in an examining bag. No claims are made that the book is a complete review of fractures and their treatments. It serves the purpose for which the author prepared it very nicely. That is, it is an excellent arrangement of fracture illustrations with an outline type of text which meets the student's needs nicely.

Lenox D. Baker, M.D.

THE YEAR BOOK OF ORTHOPEDICS AND TRAUMATIC SURGERY (1959–1960 SERIES). Ralph K. Ghormley, M.D., (Deceased) and H. Herman Young, M.D. With a Section on Plastic Surgery by Neal Owens, M.D., F.A.C.S., F.I.C.S. Chicago, The Year Book Publishers, Inc., 1960.

Dr. Young has stepped in to finish the work commenced by the late Dr. Ghormley.

The general format of the volume is the same as in previous years, with the additional inclusion of a chapter on experimental orthopaedic surgery and a complete section on plastic surgery. The authors have successfully reviewed the pertinent literature of the previous year. The volume affords a ready reference and a most adequate summary of each article, including pertinent charts, drawings, and roentgenograms.

Dr. Young, on occasion, uses his privilege of editorial comment to great benefit to temper, without distracting, some of the articles as reviewed in their original factual fashion. Some of these comments deserve an article in themselves, such as the author's plea for routine tetanus-toxoid immunization.

Most orthopaedic surgeons will find little, if any, value in occasional articles in the section on plastic surgery dealing with hypospadias, rhinoplasty, and fascial neoplasm. This chapter, however, does not detract from the over-all usefulness of the Yearbook for the busy orthopaedic surgeon, who may, through no choice of his own, be unable to keep up with all the available orthopaedic literature.

Dr. Young has ably filled the shoes of his predecessors, and the volume is heartily recommended.

William R. MacAusland, Jr., M.D.

THE MANAGEMENT OF FRACTURES AND SOFT TISSUE INJURIES. The Committee on Trauma, American College of Surgeons. Philadelphia, W. B. Saunders Company, 1960. $5.00.

Dr. Cave and his committee are to be commended on the preparation of this excellent, almost pocket-size seventh edition of "An Outline of the Treatment of Fractures" and the second edition of "Early Care of Acute Soft Tissue Injuries", which covers everything from aphorisms to snake bites. The authors outline the purpose of the book and point out that "the student must understand what causes a fracture, what a fracture is, how it heals, and what measures should be taken during the care of the lesion". The book covers each of these aspects of fractures and does it well in a clear, concise, explanatory method. Although prepared primarily for the student, the book is sufficiently complete in its coverage to serve as a guide for anyone responsible for treating trauma. The illustrations are well prepared, instructive, and helpful. Directions for roentgenographic studies are excellent. The book should be on the shelf of every emergency room and is a must for the medical student.

Lenox D. Baker, M.D.

NEOPLASMS OF BONE AND RELATED CONDITIONS. ETIOLOGY, PATHOGENESIS, DIAGNOSIS, AND TREATMENT. Ed. 2. Bradley L. Coley, M.D. New York, Paul B. Hoeber, 1960. $30.00.

The title delineates an enormous fie'd to be presented and the reader expected as much after noting the price of the book. One gets an idea of what is to come in the introduction to Section I where on page 5 the following is set down, "the periosteum, or enveloping fibrous membrane, is an important structure. Directly beneath it and outside of the underlying bone there is a potential space which contains osteoblasts. Although these are constantly present, they vary in numbers and in activity. For instance, when there is an acute infection in the medulla they pour into the subperiosteal space in large numbers, whereas in the early phases of periosteal injection or after acute trauma, they leave this area for the interior of bone. *It is considered probable that there is a constant flow to and fro of osteoblasts into and from the subperiosteal space by means of the tiny canaliculi and the more specialized Haversian and Volkmann's canals.*" (The italics were not in the original text.) This concept is so untenable that further comment seems unnecessary. In the belief that further normal anatomy should be presented, one finds on the same pages in the explanation of endochondral-bone formation the following, "this vascularization stage marks a transition of great significance for with the entrance of the blood vessels and the contact of blood with the cartilage cells a change comes over the cytoplasm—it disintegrates and the cartilage cell now acquires the

property of assimilating calcium and of depositing it in the surrounding tissue. The osteoblast is now active." To be sure that the author meant that he thought the dying chondrocytes became transformed into osteoblasts one needs only to read further on page 5, "Here there are projections and recesses which permit circulating body fluids to come into direct contact with the cartilage cells of the epiphyseal plate, and it is here that these same cells take on the characteristics and functions of osteoblasts."

Aside from a chapter on chondrodystrophia calcificans congenita and a discussion of osteomalacia and senile osteoporosis in a chapter on Blood Chemistry in Diagnosis of Diseases of Bone, the expression "related conditions" in the title must include trauma, vitamin deficiencies, endocrine disorders, metabolic disorders, disturbances of blood supply, and even chemical poisons, since these subjects are also presented.

In reading chapters devoted to a specific pathological entity, for example, benign chondroblastoma of bone, Chapter 12, one finds superb roentgenograms of a proximal humeral chondroblastoma but on the opposite page is a roentgenogram showing "secondary chondrosarcoma arising in an osteochondroma of the scapula" and the exact relationship is not clear. The photomicrograph of benign chondroblastoma is selected from what most pathologists would consider a very atypical area of such a tumor and since it is the only photomicrograph shown, it is misleading.

In discussing hemangioma of bone, he states that "Investigators have determined from large series of [necropsy] such examination that it is present in 10 per cent of individuals autopsied." He continued with "It is of vast importance that a diagnosis be reached and treatment instituted before compression and resulting myelitis occurs" and further under Treatment states that "Irradiation has been used with good results" and "as the process is not particularly radiosensitive it is necessary to give fairly large doses—." One must conclude that if these data and recommendations are correct, 10 per cent of all individuals necropsied should have had fairly large doses of x-ray therapy.

The chapter devoted to the use of bacterial products on tumors of bone is interesting. The author states that "In primary reticulum cell sarcoma of bone, however, it has seemed to us that the toxins are effective, and in this type of tumor we use them regularly in conjunction with roentgen therapy and nitrogen mustard." He does not recommend the toxin for most forms of cancer, however.

This book is beautifully printed and has long bibliographies and can be recommended only for those students who already have a vast knowledge of orthopaedic disorders.

H. Robert Dudley, M.D.

SURGERY IN THE AGED. Frank Glenn, M.D., S. W. Moore, M.D., and John M. Beal, M.D., Editors. New York, The Blakiston Division, McGraw-Hill Book Co., 1960. $17.50.

This book has a place in surgical works and should find readers among those who wish to be apprised of current surgical knowledge in succinct fashion. Although it has selected the age group it wishes to talk about, the book could find an audience among medical students as well as surgeons since it primarily discusses the entity rather than the details of surgical technique.

For the specialist Part I dealing with fundamental concepts is a particularly valuable portion of the book. The various authors manage to avoid a complicated theoretical discussion of "why", which is not the province of this text, and dwell on the facts as they are known today. For those looking for a speedy review from someone who has culled the facts a section such as that dealing with the various antibiotic agents is especially valuable. Liver function as an important factor in mortality is emphasized. The psychological condition of the patient, although a tribute to the educational campaign of our colleagues with a psychiatric bent, has always been a consideration in the armamentarium of a good surgeon. However, to see it noted in a text and discussed is good. It would not ever have been discussed in past decades in a surgical volume.

The discussions of specific entities, such as a cancer of the various regions, are good teaching presentations.

From the orthopaedic point of view the section on trauma does quite well with a good conservative approach to fractures in the aged. One cannot help but admire the incredible marksmanship required of the hip nail which backs out smack up against the backout plate. The inversion of the Moore prosthesis in the following figure is assumed to be typographical rather than an innovation of technique. The discussion of complications is excellent. Not everybody would agree that the very vascular bone of Paget's disease heals slowly, and there is perhaps a clearer concept of how to deal with fractures in this disease.

This is not a great book, but it is a useful book. It mirrors the surgical practice of a great hospital and is at a level and standard of care that is excellent. For those desiring a useful review and a clear statement of the problems encountered in surgery of the aged it makes worth-while reading. It is not necessary to read reams of irrelevant material. The illustrations are scanty but

usually present a point, often in chart form. In general, they are well chosen and are not used merely as filler.

The problem of surgery in the aged is here and is not going to diminish with time. It is important enough to the physician doing his best for the patient that he ought to find out what an excellent group of surgeons think is important about it.

A. B. Ferguson, Jr.

CHEMICAL OSTEOSYNTHESIS IN ORTHOPAEDIC SURGERY. Michael Mandarino, M.D. Springfield, Illinois, Charles C. Thomas, 1960. $4.50.

This book is a monograph of approximately sixty text pages which is divided into six major chapters dealing with the development and use of polyurethane foam in orthopaedic surgery.

The first chapter entitled "History and Chemistry" deals primarily with the details of the chemistry involved. In discussing the final properties desired for chemical osteosynthesis, it is stated that the substance used should be "non-allergenic and non-toxic". The second chapter entitled "Tissue Response to Ostamer" opens with the following sentence: "Metallic internal fixation of long bones leaves much to be desired, particularly in fresh traumatic wounds", yet later in the text (page 39) the use of steel inserts is advised for reinforcement of polyurethane foam in treating certain fractures of the tibia. It is stated that "guinea pig intraperitoneal implants produce no toxic results". This, however, is not in accordance with the findings of W. C. Hueper (J. Am. Med. Assn., Vol. 173, 860, June 18, 1960) who reported as follows: "It was found that polyurethane foam, when implanted either as a sponge or as a powder into the abdominal cavity of rats, produced not only sarcomas but also adenocarcinomas of the cecal mucosa at the sites where the polymer was in contact with, and became adherent to, the intestinal wall". Hueper concluded that these observations should caution against indiscriminate use of polyurethane plastics in medical practice and their use should not be considered without proper previous long-term investigations on possible carcinogenic sequelae. Chapter Three entitled "Histology" reports the findings in three dog femora which were fractured and treated with polyurethane foam. No comparative or controlled studies are included.

Chapter Four entitled "Indications for Surgery" lists non-union, pathological fractures, bone cysts, acute fractures that are prone to complication, and spine fusions as the principal indications for polyurethane fixation. It is also stated that infection is no contra-indication to its use. In discussing bone cysts and giant-cell tumors, it is stated that polyurethane foam can be applied in any instance in which bone chips could ordinarily be used. A very sweeping statement then follows: "It would be negligent indeed to treat this type case in any way other than with Ostamer". In discussing spine fixations "in numerous cases", it is stated that all of the spine cases fixed with polyurethane foam have had excellent clinical results, yet satisfactory documentary evidence is not offered in support of this statement. Chapter Five deals with "Techniques of Surgery". In discussing long-bone fractures, the use of an inlay bone graft and, if the medullary canal is small, the use of an intramedullary support or rod are advised in conjunction with polyurethane. A group of five illustrations (Fig. 15) used in conjunction with this have no individual captions and descriptions given in the texts often leave the reader confused. The final chapter deals with fifty patients operated on by the author, with thirteen cases reported in detail. The maximum follow-up study reported was apparently thirteen months (Case 3), while in some cases no follow-up study was indicated. The cases illustrated do not adequately substantiate the 94 per cent successful results which the author states has been obtained in a total of 300 reported cases as of September 1, 1959.

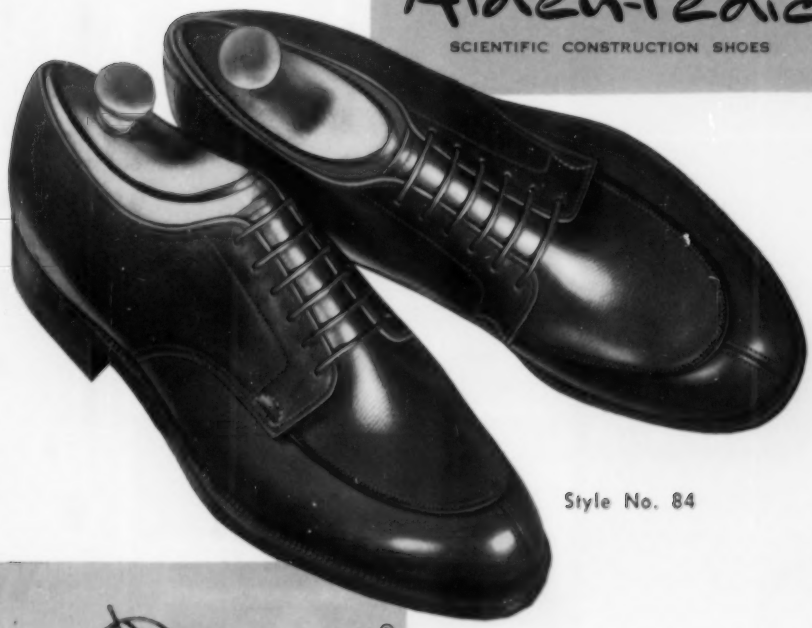
Since the material submitted by the author does not justify the conclusion that the use of polyurethane foam is superior to other forms of internal splinting long used in reconstructive surgery of bone defects, and since the toxic and carcinogenic properties of this substance have not been accurately determined, the book and the surgical principle which it proposes cannot be recommended. More evidence, both experimental and clinical, must be accumulated before the merit of this principle can be verified.

H. R. McCarroll, M.D.

THE MOST
MODERN APPROACH
TO FOOT PROBLEMS

Alden-Pedic

SCIENTIFIC CONSTRUCTION SHOES



Style No. 84

FOOT BALANCE®

SHOES AND LASTS
SERVE 3 PURPOSES

- ✓ LASTS DESIGNED TO FIT INDIVIDUAL FOOT TYPES
- ✓ ACCOMMODATE PRESCRIBED CORRECTIONS
- ✓ PROVIDE A STABLE CONTROLLED FOUNDATION

Progress Through Research

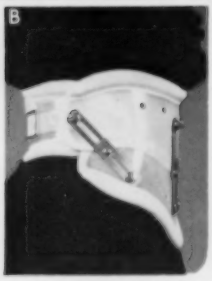
C.H. ALDEN SHOE COMPANY

Custom Bootmakers Since 1884

BROCKTON, MASSACHUSETTS

WRITE TODAY
FOR OUR PROFESSIONAL
CATALOG AND NAME OF
YOUR NEAREST DEALER.

LIGHT WEIGHT · WASHABLE · ADJUSTABLE



CERVICAL COLLARS FOR EXTENSION-FLEXION OR STABILIZATION

A & B **THE EXTENSION-FLEXION COLLAR** — A universal cervical collar, extremely versatile and adaptable for extension, flexion, or stablization.

C **The MYO-VENT** A one-piece extension collar with ventilated adjustability.

D **The CER-VENT** Extension Model. A one-piece collar with ventilated adjustability. Easy to put on, complete support.

E **The CER-VENT** Flexion Model. A one-piece collar with ventilated adjustability. Easy to put on, complete support.

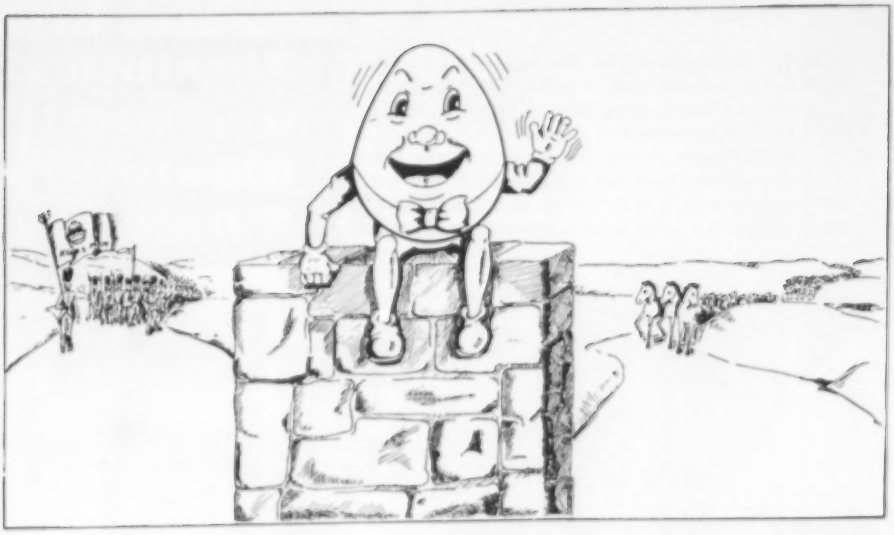
F **The MYO-CERVICAL** A one-piece extension collar with overlapping adjustment.

Catalog and Order Blanks upon request.

FLORIDA BRACE CORP.

601 Webster Avenue « » Post Office Box 1366

Winter Park 3, Florida, Telephone Midway 4-2650



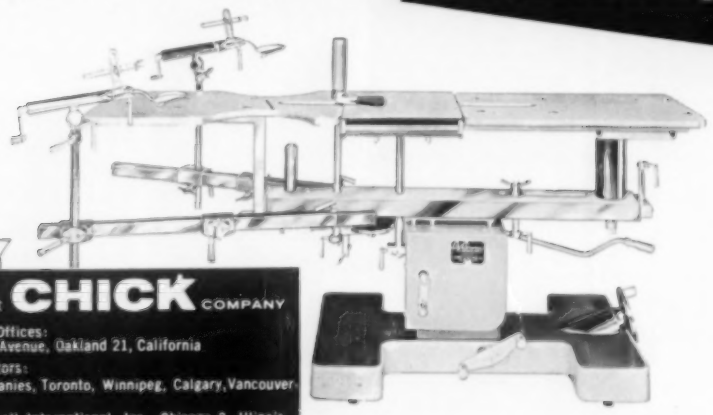
Humpty Dumpty sat on a wall
Humpty Dumpty had a great fall,
All the king's horses and all the king's men
Couldn't put Humpty Dumpty together again.

Because . . . In that day they did not have

The RUSH® MEDULLARY PIN
Pat. No. 2,579,968

Flexibility is the keynote of Chick DVHI Orthopedic and Surgical Table. Featuring variable height, it employs a self-contained hydraulic unit with built-in safety factor. Table tilts laterally and offers Trendelenburg position of 15°, **reverse Trendelenburg of 7½°**. Other outstanding features include **new foot-locking device for positive table positioning** and carriage-mounted Chick Transverse Cassette Tunnel. DVHI is ideal for all Orthopedic surgery, most general surgery, and all cast work. Write today for information.

Flexibility Insures Maximum Efficiency



GILBERT HYDE **CHICK** COMPANY

Plant and Sales Offices:
821 - 75th Avenue, Oakland 21, California

Canadian Distributors:
The Stevens Companies, Toronto, Winnipeg, Calgary, Vancouver

Exporter:
J. D. Marshall International, Inc., Chicago 2, Illinois

Manufacturers and Distributors of
Hospital Orthopedic and Fracture Equipment

Third Fabrication of the Original Edition

Atlas of Rush Pin Technics

by Leslie V. Rush, M. D.

A picture book with commentary. Exhaustively demonstrates unique methods of exact reconstruction of fractured bones. Quite different in principle and technic from other forms of intramedullary fixation.

FROM FOREWORD TO GERMAN EDITION

Translated into German by Dr. Heinz Gelbke, Professor of Surgery, Director of the Surgical Clinic of the University of Gottingen. Foreword by Dr. H. Hellner, Chief of Surgery, University Clinic, Gottingen.

". . . I am convinced of the great value of this technic, as witnessed by numerous fractures which were operated upon by this method at the Surgical Clinic of the University at Gottingen. I am particularly impressed by the possibilities of exact treatment of fractures near joints which is in addition to the excellent method of Kuntscher, and which is founded on completely different technical basis and principles.

"I also found the explanation of Rush so original, educational and interesting that I feel it an excellent idea of Gelbke to bring this Atlas in German to German surgeons.

"Progress always breaks through. It will take a little time to learn the method. But the one who masters the method, and it is not hard to learn, will have much use for it with his injured and enjoy using it himself.

227 Pages — 895 Illustrations — Price $10.00

MFG EXCLUSIVELY BY:

THE BERIVON Company
P O BOX 1851
Meridian, Miss.

NEW *Richards* EBONIZED STAINLESS FINISH STOPS REFLECTED GLARE

Now **ebonized stainless** — another product of Richards research — increases the working efficiency of surgical instruments. The finish, a dull ebony color, contrasts sharply with light tissue tones . . . and does not reflect glare from brilliant overhead spotlights. This heightened contrast brings the contour of instrument against operative area into clear focus — reduces eyestrain and fatigue, increases operating speed, ease, and efficiency.

Richards unique finishing process removes impurities from the pores of the metal and assures permanence. Repeated autoclaving will not affect the finish in any way.

For full details, write:

Richards MANUFACTURING COMPANY

756 Madison Avenue Memphis 3, Tennessee

The Straight Last...
friend to all
young feet!

It's no wonder doctors praise the versatility of this foot covering. Basically can be worn by a normal foot, yet the Junior Arch Preserver shoe built on a true straight last may be fitted with whatever wedging and pads you indicate for your youthful patient's special prescription. All Junior Arch Preserver shoes are constructed by Medic craftsmen to the most exacting standards . . . in a wide variety of lasts that make it easy to meet each child's shoe needs. They're the finest value in children's shoes . . . safe and sound to prescribe and recommend to your patients.

For the name and address of the store nearest you carrying Junior Arch Preservers, write today to

Junior ARCH PRESERVER *Shoes by* MEDIC

MEDIC Shoe Manufacturers, Inc.
1212 Wood Street, Philadelphia 7, Pa.

The complete line of feature shoes for children that doctors recommend

DESIGNED FOR COMFORT!

The TEARE
ARM SLING

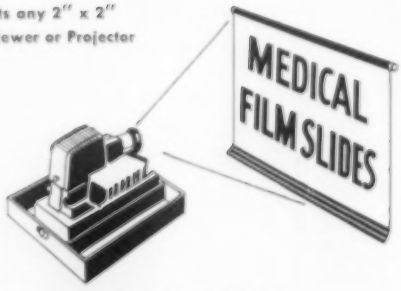
U.S. Pat. 2524677
Canada Pat. 481291

COMFORT SIZES FOR ALL!

In White Cotton—adult, child and extra small child sizes
In Black Cotton and Plastic—adult size only
TIME SAVING • ADAPTABLE • SCIENTIFIC
Write for Nearest Distributor

Mfd. exclusively by
M. M. TEARE CO., INC.
Dept. JB, 209 Melrose Bldg., Buffalo 10, New York

Fits any 2" x 2"
Viewer or Projector



TYPICAL SERIES

6-1 **Congenital and Developmental Osseous Abnormalities** . . . . . 52 Slides
6-2 **Osseous Abnormalities, related to Reticuloendothelial System, Vitamin Metabolism, and Circulatory Disturbances** . . . . . 55 Slides
6-3 **Osseous Abnormalities, related to Metabolic Diseases, Parathyroid Dysfunction, and Infectious Disease** . . . . . 55 Slides
6-4A **Bone Tumors** . . . . . 53 Slides
6-4B **Bone Tumors** (Continued from Series 6-4A) . . . 53 Slides

Herbert M. Stauffer, M.D., Edward E. Christensen, M.D., Temple University Hospital, Philadelphia

ORDER DIRECT OR WRITE for complete description of above series, and catalog of others that are available.

Price per series $16.50

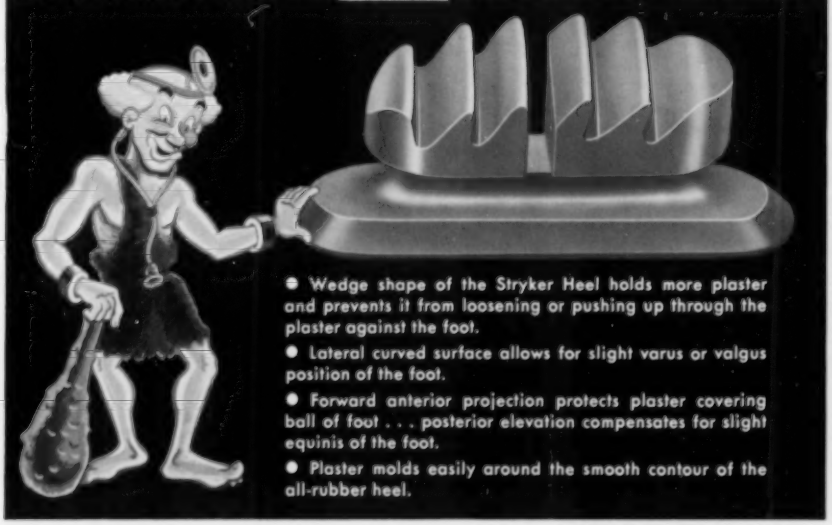
MXRR
MEDICAL FILM SLIDE DIVISION
MICRO X-RAY RECORDER, INC.
3755 W. Lawrence • Chicago 25, Illinois

NEW! *RIPPLE® HEEL

for walking casts

A Stryker EXCLUSIVE!

DO YOU KNOW WHY THE STRYKER WALKING HEEL IS SUPERIOR?



- Wedge shape of the Stryker Heel holds more plaster and prevents it from loosening or pushing up through the plaster against the foot.
- Lateral curved surface allows for slight varus or valgus position of the foot.
- Forward anterior projection protects plaster covering ball of foot . . . posterior elevation compensates for slight equinis of the foot.
- Plaster molds easily around the smooth contour of the all-rubber heel.

Here's the finishing touch to the finest walking heel made.

The comfortable, cushioned action of the well-known patented RIPPLE® Sole used extensively for ordinary footwear, is preferred by all patients who have tried both types of walking heels during extensive comparison tests.

The RIPPLE® Sole principle absorbs walking shock, compresses when walking to convenient distance from floor, and provides better traction on slippery surfaces.

Per doz. $15.00

OFFICE MODEL **$24.50** Each

THE Stryker CAST SPREADER

The secret to the popularity of Stryker Cast Spreaders is in the *strong interdigitated teeth* that fit easily without wedging plaster into the slot made by the cast cutter.

A protective guard keeps the blade from advancing into the plaster and pinching the skin.

Set of 2 . . . $45.00

HEAVY DUTY MODEL Overall Height 19½" **$24.50** Each

Stryker

SURGICAL AND HOSPITAL EQUIPMENT

Orthopedic Frame Company

420 ALCOTT STREET • KALAMAZOO, MICHIGAN

* T. M. RIPPLE SOLE CORP.

HARVARD MEDICAL SCHOOL

Courses for Graduates

presents

SYMPOSIUM ON "THE HAND AND WRIST"
April 14 and 15, 1961

at

The Massachusetts General Hospital

by Members of the Orthopedic and Fracture Services and Other Staff Members of the Massachusetts General Hospital

This one-and-a-half day symposium is presented to review the present methods of surgical and conservative management of acute injuries to the hand and wrist. Methods of nerve and tendon repair will be illustrated.

Surgical treatment of the arthritic hand and acquired and congenital deformities of the hand and wrist will be specifically discussed and illustrated.

Changes in the hand produced by systemic disease as shown by X-ray examination will be reviewed.

Tuition—$50

Apply to Assistant Dean, Courses for Graduates
Harvard Medical School, Boston 15, Massachusetts

CORNELL UNIVERSITY MEDICAL COLLEGE

ANNOUNCES THE SIXTH ANNUAL POSTGRADUATE COURSE IN

The Treatment of Fractures and Other Trauma

at

The Hospital for Special Surgery and New York Hospital — Cornell

JUNE 12-17, 1961

This six-day course is given annually by members of the Cornell University Medical College faculty, serving on the staff at the Center hospitals. In addition to fractures and dislocations, the program offers a comprehensive review of the treatment of other traumatic conditions, including burns, shock, hand injuries, and trauma to abdomen, chest and nervous system.

Living accommodations will be available to postgraduate students and their wives in the Cornell Medical Student Residence, Olin Hall, at $5.00 per person per night.

TUITION: $150.00 — Enrollment limited
For further information write to:
DR. PRESTON A. WADE
Cornell University Medical College
1300 York Avenue
New York 21, New York

WANTED

Orthopedic Surgeon

Board Certified or Eligible

To establish full-time private practice with membership in and affiliation with Medical Staff, Charleroi-Monessen Hospital, North Charleroi, Pennsylvania, 28 miles southwest of Pittsburgh, serving population of 150,000. Address inquiries to J. R. CONNELLY, M.D., *Secretary*, Medical Staff, setting forth qualifications and personal history. Arrangements will be made and transportation expenses will be paid upon arrival for interested physicians to visit hospital.

ACTIVE HAND and FINGER SPLINTS

Instruments for Hand Surgery and Treatment

AS DESIGNED BY
Dr. STERLING BUNNELL

Carried in stock for immediate delivery

- Knuckle bender splint
- Radial palsy splint
- Finger extension splint, etc.
- Hand Drill w/Jacobs chuck
- Tendon stripper set
- Gig pull-out suture and

other special instruments for bone and joint surgery

▶ *Write for catalogue — postage prepaid* ◀

H. WENIGER

Established 1907

New Address

70-12th Street, San Francisco 3, Cal.

SAFER and QUICKER MENISCECTOMIES with BOWEN Instruments

Grover Meniscectome

Used through any arthrotomy exposure and on either semilunar cartilage, it guarantees the integrity of all structures within the joint and permits complete removal of either meniscus.

Designed like a large intra-uterine curette, it presents a smooth rounded guard on the outer surface of the ring, the inner margin of which is a keen knife edge permitting cutting in any direction. Its use will shorten by about one-third the present operating time.

Standard Length: 8½″ • No. 128

Smillie Cartilage Sets

Designed with handles that do not obscure field of vision. Longer back always rests on tibial table. Beaked knife divides the peripheral attachments of the medial meniscus. Also divides the central attachment of the posterior horn of the lateral meniscus. Second beaked knife used for the same purpose, also to divide the central attachment of the posterior horn of the medial meniscus. Chisel mobilizes middle third of the meniscus.

No. 108

(Curved Shank)

ILLUSTRATIONS SHOW POSITIONS OF KNIVES IN USE

No. 126

(Straight Shank)

Smillie Knee Joint Retractor Set *(Stainless Steel)*

The angles of the blades and the modified handles of these retractors have been altered to give a better grip and keep the fingers away from the incision. They are exceptionally well designed for the removal of menisci and for use in practically all knee joint operations. The set of four comprises one hook and three with blade lengths from 1½ inches to 3 inches.

FEATURES: "Sure grip handles for perfect control." • "Hardened and tempered to rigid specifications." • "Useful retractors for many other surgical procedures."

No. 145 Knee Joint Retractor Set—$30.00
(Four Pieces)

Priced Individually at $8.00 each

New!

Unique!

BOWEN Liquid DISPENSER

For the dispensing of alcohol and other cleansing liquids.

Patent Applied For

- *Quick Acting • Unbreakable • Will Not Tip*
- *Easily Operated with one hand*
- *To Use, Just Press on Metal Plate!*

ONLY **$1.50**

BOWEN & COMPANY, INC.

P. O. BOX 5818
BETHESDA, MARYLAND

FOR TREATMENT OF SPASTIC CASES • CEREBRAL PALSY • STROKE • POLIO • HAND INJURIES

General Electric Co. Silicone

BOUNCING PUTTY

As a "trial order" send $2.00 for one $2.85 jar

does not harden
lasts indefinitely
and can be
autoclaved.

S. R. GITTENS, *Distributor,* 1620 Callowhill St., Phila. 30, Pa.

THE RUTH JACKSON COLLAR

The Ruth Jackson collar, providing maximum occipital support, will maintain, with a high degree of comfort, the flexed position with chin tucked in, recommended by Ruth Jackson, M.D., F.A.C.S., in her book "The Cervical Syndrome."

"Collars or braces should be designed to hold the neck in the optimum position for healing . . . This position must be with the neck straight and the chin 'tucked in'. Braces which hold the neck in hyperextension are completely wrong in principle . . ."
THE CERVICAL SYNDROME by Ruth Jackson, B.A., M.D., F.A.C.S., publisher Charles C Thomas, Springfield, Ill.

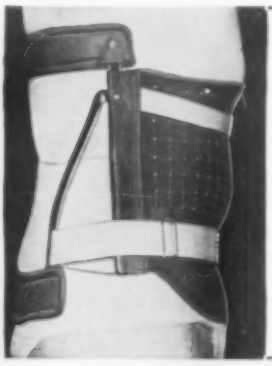
THE EXO-STATIC COLLAR
(completely redesigned)

The Exo-Static collar, while it may be adjusted for full extension, may also be lowered to a point of slight flexion and provides stabilized support, not only to the chin, but laterally and to the occiput, *automatically adjusting to the proper occipital height corresponding to the extension required.*

FLORIDA MANUFACTURING CORPORATION

BOX 449 • DAYTONA BEACH, FLORIDA

Reprint from Chapter on Treatment in "Cervical Syndrome" available on request



The "ORIGINAL"
WILLIAMS lumbo-sacral flexion back brace—
designed by Dr. Paul C. Williams

"To reduce the lumbo-sacral lordosis and thus lift the weight from the posterior vertebral structures. Permits free ant. flexion of the lumbar spine but prevents extension and lateral flexions."

Measurements

1. Chest (about 4" below nipple line)
2. Waist (at navel line)
3. Pelvic (½ distance between greater trochanter and crest of ilium)
4. Back (seventh cervical spinous process to the prominence of coccyx.)

Order filled at the request of members of the profession only

MILLER BRACE COMPANY

(Established in Dallas since 1932)

3902 Gaston Avenue **P.O. Box 7902** **Dallas, Texas**

A MODERN CORRECTIVE SHOE
FOR EVERY *Orthopedic* NEED

TARSO SUPINATOR®
For the postural correction of flat feet.

TARSO PRONATOR®
For club feet and metatarsus varus. Pairs or single shoes.

TARSO MEDIUS®
Straight, neutral last shoe. Detailed to match Tarso Pronator. Pairs or single shoes.

Tarso shoes are fitted on prescription at better shoe stores. Write for nearest dealer or use your regular supplier. Brochure on request.

M. J. MARKELL SHOE COMPANY, INC.
332 S. Broadway, Yonkers, N. Y

SABEL'S

BASIC SHOES
TRADE MARK REG. U. S. PAT. OFF.

offers you the

COMPLETE
BASIC SHOE PROGRAM

From basics to highly specialized footwear, Sabel covers the field.

Shoes made on scientifically designed lasts that have been developed through direct contact with doctors and hospitals across the country . . . shoes that accept corrective measures, yet retain style features . . . shoes for boys and young men . . . surgical boots for post-operative cases for men and boys.

Sabel has the COMPLETE shoe program, all styles carried in stock for immediate delivery . . . plus 35 years of experience in the basic shoe business.

No. 772 Tan Calf
No. 672 Black Calf

No. 870 Tan Calf
No. 653 Black Calf

Manufactured exclusively by
C. H. ALDEN SHOE CO.

I. SABEL Inc., 1207 Chestnut St., Philadelphia, Pa.

For Congenital Dislocation of the Hip—ORDER

FREJKA
ABDUCTION PILLOW SPLINTS

with the new Wet-Proof pillow

3 SIZES:
Small—6" pillow splint (up to 4 months)
Medium—9" pillow splint (4 to 8 months)
Large—12" pillow splint (over 8 months)
Available in Pink, Yellow & White

PHONE—Midway 4-6874

MINNESOTA ORTHOPEDIC SERVICES
1963 Carl Street St. Paul 13, Minn.

PRICE

With Extra Halter $12.50

POSTPAID

NOW READY

To Enable You to Find Quickly
All Journal Papers on Any Subject
Published in the Past Ten Years
In Either the American or British Volumes

THE SUBJECT BIBLIOGRAPHY

1948-1957

of

The Journal of Bone and Joint Surgery

Four main sections, ANATOMY, DISEASE, TREATMENT, RESEARCH.

Six hundred and ninety-nine subject classifications.

Extensive cross-references. For example, a paper on *tendon transfer in the paralysed hand* will be found in the ANATOMY section under HAND, in the DISEASE section under PARALYSIS, and in the TREATMENT section under TENDON TRANSFER.

Author index.

Every listing gives entire title of the paper, authors' names, volume, pages, month and year, and, where necessary, information defining the scope of the paper. Listings on each subject are in chronological order.

The SUBJECT BIBLIOGRAPHY is uniform in size and binding with an issue of *The Journal*.

Price $6.00 through Boston — *or* — £2.3.0 through London

The Journal of
Bone and Joint Surgery
8 The Fenway
Boston, Massachusetts

The British Society of
Bone and Joint Surgery
82 Portland Place
London W.1, England

PRESTON *A Complete Line* **FOR PHYSICAL THERAPY AND REHABILITATION**

REHABILITATION: **Bicycle Exercisers; Restorator; Walking Parallel Bars and Exercise Staircases** of various designs; Posture Mirrors; Gymnasium Mats; **Shoulder Wheels** with or without height adjustment; **Elgin Progressive Resistance Exercise Units;** Quadriceps Boots; Dumbbells; Chest Pulley Weights; **Standing (Tilt) Tables; Stryker Turning Frames.**

HAND THERAPY DEVICES: Kanavel Table; Manuflex; Wrist Exercisers; Complete Line of **Bunnell Splints;** Theraplast.

TRACTION: Many types of Cervical and Pelvic Traction Sets; **Hausted Tractionaid.**

HYDROTHERAPY — ELECTRO THERAPY: **Whirlpools;** Paraffin Baths; **Hydrocollator;** Ries Moistaire; **Medcolator** and other Low-Volt Generators; Infrared Lamps; Bakers; **Birtcher Ultrasonic Generators.**

Everest & Jennings Wheelchairs; Commodes; **Walkers** and Walking Aids for every need; **Hydraulic Patient Lifters;** Largest selection of **Treatment Tables.**

Complete Line of Cerebral Palsy Equipment —Speech Therapy —**Self Help Devices for the Handicapped.**

JUST OFF THE PRESS!

THE ALL-NEW PRESTON CATALOG #1065

- Features *today's most complete line* of Equipment for Physical Therapy and Rehabilitation.
- 208 profusely illustrated pages . . . over 2500 product listings, including many new items of interest to you.
- Your one dependable guide in ordering Physical Therapy Equipment.

SEND FOR YOUR FREE COPY TODAY

We supply *ALL EQUIPMENT* for setting up a complete Rehabilitation Program. Suggested layouts and equipment lists are available to you through *OUR FREE PLANNING SERVICE.*

J. A. PRESTON CORP., 175 FIFTH AVENUE, NEW YORK 10, N. Y.

List of Advertisers

MARCH 1961

	PAGE
Airloom Bedding Company	16
C. H. Alden Shoe Company	41
American Sterilizer Company	13
Austenal Company	34, 35
Bauer & Black, Division of the Kendall Company	6, 7, 30
The Berivon Company	43, 44
Bowen & Company, Inc.	49
S. H. Camp and Company	28
Charleroi-Monessen Hospital	48
G. W. Chesbrough Co.	12
Gilbert Hyde Chick Company	44
Conco Surgical Products, Inc.	37
Cornell University Medical College	48
DePuy Manufacturing Company, Inc.	5
J. Edwards Shoe Company	4
Florida Brace Corporation	42
Florida Manufacturing Corporation	50
S. R. Gittens	50
Hack Shoe Company	27
J. E. Hanger, Inc.	24
Harvard Medical School	48
Herbst Shoe Manufacturing Company	22
House of Bidwell, Inc.	53
Lederle Laboratories, Division of American Cyanamid Company	20, 21
M. J. Markell Shoe Company, Inc.	51
Medic Shoe Manufacturers, Inc.	46
Medical Research Specialties	17
Merck Sharp & Dohme, Division of Merck & Co., Inc.	19
Micro X-Ray Recorder, Inc.	46
Miller Brace Co.	50
Minnesota Orthopedic Services	51
V. Mueller & Co.	8
Orthopedic Equipment Co.	40
Orthopedic Frame Company	18, 47
J. A. Preston Corp.	53
Richards Manufacturing Company	33, 45
Zack Rogers Associates, Inc.	29
I. Sabel, Inc.	51
Chas. A. Schmidt Surgical Instrument Company	26
J. Sklar Manufacturing Co.	23
Spencer, Incorporated	31
M. M. Teare Co., Inc.	46
Truform Anatomical Supports	9
Wallace Laboratories, Division of Carter Products, Inc.	10, 11, 26, 32
Wallace Orthopedic Manufacturing Co.	25
H. Wenger	48
Wright Manufacturing Company	38, 39
Zimmer Manufacturing Company	14, 15

To serve your complete needs in
ORTHOPEDIC, PROSTHETIC
and SURGICAL APPLIANCES

house of BIDWELL inc.

535 N. 27th Street
Milwaukee 8, Wis.

1134 Regent St.
Madison, Wisconsin

Dear Subscriber:

There is so much "family feeling" between The Journal and its subscribers that we are going to ask your help in a family problem.

We maintain our own subscription records. Every new subscription, renewal, change of address, order for back issues, inquiry, and complaint goes through the hands of a staff who almost know the subscriber files by heart. This is perhaps old-fashioned but we believe it results in better service than would any impersonal, mechanized system.

The natural busy time for the subscription department is the end of the year because most renewals start in January. This is right and proper.

This is our sad story —

The peak load of the subscription department continues through January, February, March and into April because of the *extra* work caused by renewals that come in late, that is, that are received after an issue has been missed. It takes more than three times as much time and bookkeeping to take a name off the lists and put it back as it does to record a prompt renewal. It is also frustrating work because you undo on Tuesday what you did on Monday.

Please send your renewal check early!

Thank you

1961 Subscription Prices

The Journal of Bone and Joint Surgery

American Volume $14.50

Eight Issues

January	July
March	September
April	October
June	December

British Volume $7.50

Four Issues

February	August
May	November

Both Volumes $22.00

Twelve Issues

All Single Issues $3.00
All Back Issues $3.00

Subscriptions and Renewals to Both Volumes may be sent to either

The Journal of
Bone and Joint Surgery
8 The Fenway
Boston 15, Massachusetts

or

The British Society of
Bone and Joint Surgery
82 Portland Place
London W.1, England

Sterling prices

American Volume £5.4.0
British Volume £2.13.6

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

ADDRESSES OF CONTRIBUTORS
MARCH 1961

Thomas A. Angelo, M.D., The Wanless Hospital, Mission Hospital P.O., Miraj, India

William Bora, M.D., Massachusetts General Hospital, Boston 14, Massachusetts

Harold B. Boyd, M.D., 869 Madison Avenue, Memphis 3, Tennessee

Harold A. Collins, M.D., Vanderbilt University, Nashville 5, Tennessee

Ralph L. Cotton, M.D., State University of Iowa, Iowa City, Iowa

Mark B. Coventry, M.D., Mayo Clinic, Rochester, Minnesota

Lewis Cozen, M.D., 6221 Wilshire Boulevard, Los Angeles 48, California

David C. Dahlin, M.D., Mayo Clinic, Rochester, Minnesota

Thomas L. DeLorme, M.D., Massachusetts General Hospital, Boston 14, Massachusetts

J. H. Dimon, III, M.D., 1938 Peachtree Road, N.W., Atlanta 9, Georgia

James R. Donaldson, M.D., The Wanless Hospital, Mission Hospital P.O., Miraj, India

Benjamin W. Drompp, M.D., Wayne State University College of Medicine, 1401 Rivard, Detroit 7, Michigan

Adrian E. Flatt, M.D., F.R.C.S., University Hospitals, State University of Iowa, Iowa City, Iowa

J. Kenneth Jacobs, M.D., Vanderbilt University, Nashville 5, Tennessee

Laird Johnson, B.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts

Emanuel B. Kaplan, M.D., 1001 Grand Concourse, New York 52, N. Y.

S. W. Lipinski, M.D., Watson Clinic, Lakeland, Florida

Peter Luchini, B.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts

James Morrissey, M.D., Massachusetts General Hospital, Boston 14, Massachusetts

Ignacio V. Ponseti, M.D., State University of Iowa, Iowa City, Iowa

E. L. Ralston, M.D., 3400 Spruce Street, Philadelphia 4, Pennsylvania

Amin Rida, M.Ch.Orth.(Alex.), 19, Midan Saad Zaghloul, Alexandria, Egypt, United Arab Republic

Charles J. Ruth, M.D., 1999-B Mowry Avenue, Fremont, California

Paul W. Scanlon, M.D., Mayo Clinic, Rochester, Minnesota

Martin Silberberg, M.D., Department of Pathology, Washington University, St. Louis, Missouri

Ruth Silberberg, M.D., Department of Pathology, Washington University, St. Louis, Missouri

Caroll M. Silver, M.D., 225 Waterman Street, Providence 6, Rhode Island

Stanley D. Simon, M.D., 225 Waterman Street, Providence 6, Rhode Island

James H. Wiley, M.D., 869 Madison Avenue, Memphis 3, Tennessee

Joe W. Woodward, M.D., 2220 Austin Avenue, Waco, Texas